AD-A125 160 DIRECT DIGITAL BOILER CONTROL SYSTEMS FOR THE NAVY SMALL BOILER EQUIPMENT(U) ULTRASYSTEMS INC IRVINE CA FEB 83 NCEL-CR-83.015 N62474-81-C-9388 1/2

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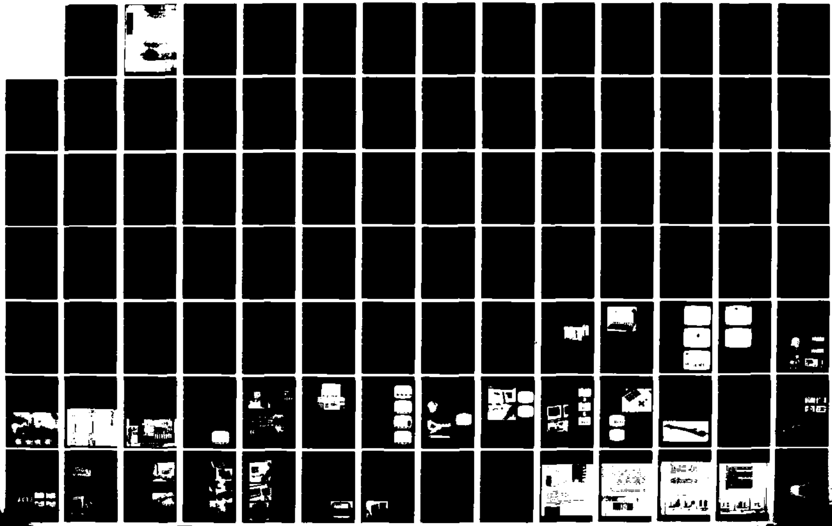
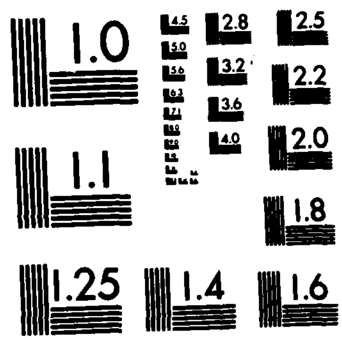




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD A125160

CR 83.015

ENGINEERING

Naval

Naval

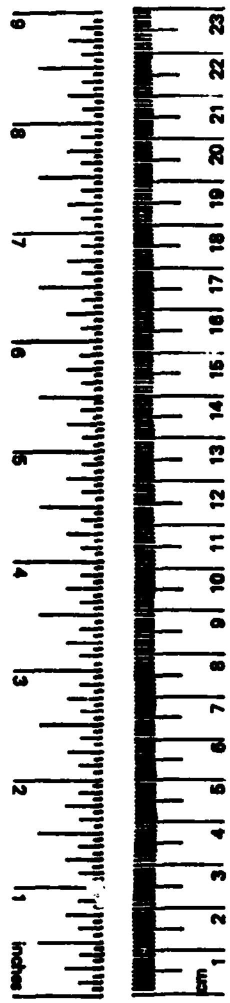
EQUIPMENT

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

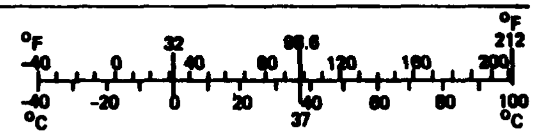
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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Direct, digital, boiler control, system distributed

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Fifteen manufacturers of direct digital boiler control systems were surveyed. The results are presented in a comparison chart supplemented by narrative discussion. Recommendations for incremental application of these systems to the Navy's small boiler control requirement are presented, as well as estimated cost projections for single and multiple boiler control application.

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DIRECT DIGITAL BOILER

TABLE OF CONTENTS

1.0 INTRODUCTION

A total of 16 direct digital control systems applicable to the Navy's small boiler requirement were identified and product information was obtained. One system now using analog controllers was included since they have digital controllers in development. Most of the systems studied employ functionally distributed control architecture wherein the controllers have resident memory and are electrically isolated from the operators station and communication link so that a failure of the operators station or communication link will not affect the control of the boiler. All of the systems are available with color CRT operators displays and keyboards etc. which are carefully thought out so as to simulate the analog displays that most operators are familiar with and thus require a minimum of operator training. A majority of the systems offer custom graphic displays for operator orientation.

2.0 SUMMARY

Any one of the digital control systems surveyed in this report is capable of providing improved control of the Navy small boilers under consideration with improved operator convenience. However, their capabilities and cost effectivity vary significantly, so a careful analysis of the total requirement and anticipated availability of funding is suggested, perhaps followed by a comparative operational test on several boilers. The results of this test can then be "matched" to the requirement so as to generate a comprehensive program for updating as many as possible of the Navy small boiler control systems. With the present and projected high cost of fuel, any program for improving the efficiency of these boilers by means of more accurate control will have a very rapid payoff on fuel savings alone, to say nothing of the added operator convenience and reduced control system maintenance.

Most of these control systems can be installed in a progressive or "stepped" program so as to spread the cost over a number of years for individual boilers. This will allow the benefits of digital control to be applied to a larger number of boilers progressively if funding is restricted. The advantages of controlling several boilers with a single operator's station and the savings due to a reduction in the number of operators required add up to a significant benefit for many installations.

3.0 CONCLUSIONS AND RECOMMENDATIONS

This survey indicates that there are many excellent direct digital control systems available to satisfy the Navy's small boiler requirement, and that they can be cost effective in the reduction of fuel usage and decreased maintenance. Any of the digital control systems surveyed could be applied to the Navy small boiler program beneficially, however, there are several which appear to be especially applicable because of low cost, arrangement, flexibility, etc. These are, in order of preference, the following:

a. Westinghouse-Hagan DCS-1700
b. Fisher-PRŌVOX
c. Robertshaw DCS-1000
d. Bristol Babcock UCS-3000
e. Micon MDC-200

In order to realize the advantages that these systems can give in cost savings and operator convenience, they must be carefully selected and properly applied. The following type of program is recommended:

1. Problem definition survey

   A thorough survey should be made of the Navy's small boilers. The primary items of interest would be:

   a. Size
   b. Location
   c. Proximity to other similar units
   d. Anticipated future use and duty
   e. Type of control system
   f. Condition of controllers
   g. Condition of sensors (transmitters)
   h. Sensor signal type
   i. Condition of valve and damper operators
   j. Signal type to valve and damper operators
   k. Is control room available
   l. Distance from control room to sensors and operators
   m. Fuel cost for last 12 months
   n. Number and capability of operator(s)

2. Analysis of survey results.
   From the results of this survey decide on a schedule of refitting based on single boilers, multiple boilers, probable availability of funding, etc.

3. Consideration of capabilities.
   Decide how many add-on features make economic sense, for instance, how many functions should be monitored only, how many should be monitored and alarmed, is a CRT-keyboard station required and what type of backup is justified. Also the question of being able to add-on features at some future time should be carefully investigated.

4. Stepped refit installation.
   A stepped refit program such as was outlined in Section 7-3 for a large number of boilers, vs a complete current installation on a small number, probably makes the most economic sense for the Navy if only limited funding is available.

5. Prepare procurement specification based on the above considerations.

6. Select the most promising system(s).
   Consideration should be given to selecting several systems, installing them on boilers in the same geographical area, and rotating the operators for training and operation so as to obtain the best possible comparison before large scale purchasing and installation is initiated.

4.0 LIST OF MANUFACTURERS

The following manufacturers offer digital control systems suitable for the control of small boilers in the size range of 30,000 to 100,000 PPH of steam. The order of listing is completely random with no ranking or preference.

A. Leeds & Northrup
A Unit of General Signal
North Walkes, PA 19454

B. Fischer & Porter
Corporate Headquarters
Horsham, PA 19044

C. Westinghouse-Hagan
Westinghouse Electric Corporation
Combustion Control Division
Orrville, OH 44667

D. Rosemount Inc.
P.O. Box 35129
Minneapolis, MN 55435

E. Beckman Instruments Inc.
Process Instruments Division
2500 Harbor Blvd.
Fullerton, CA 92634

F. Moore Products Co.
Spring House, PA 19477

G. Texas Instruments Incorporated
Industrial Controls Division
Johnson City, TN 37601

H. Robertshaw Controls Company
Digital Controls Group
700 Industrial Road
Sugar Land, TX 77478

I. Process Systems Inc.
8540 Mosely Drive
Houston, TX 77075

J. Bristol Babcock Inc.
40 Bristol Street
Waterbury, CT 06708

K. Bailey Controls
29801 Euclid Avenue
Wickliffe, OH 44092

L. Honeywell
1100 Virginia Drive
Ft. Washington, PA 19034

M. The Foxboro Company
38 Neponset Avenue
Foxboro, Mass. 02035

N. Gould Inc.
P.O. Box 83
Shawsheen Village Station
Andover, MA 01810

O. Measurex Corporation
One Results Way
Cupertino, CA 05014

P. Fisher Controls Company
P.O. Box 190
Marshalltown, Iowa 50158

5.0 COMPARISON CHART

The comparison chart included in this section as Figure 5-1 is for quick reference purposes only on a single chart, and does not pretend to be a fully descriptive delineation of the many sophisticated systems offered.

Many of the systems included have means for modifying their characteristics that may not be included in the table. In the area of cost, the numbers in the table must be considered as only a very loose guide. Generally, companies are reluctant to divulge cost information unless they bid a system for a specific defined application. However, the costs presented are the result of an objective look and are believed to be of value for preliminary comparison purposes. A reference boiler control scheme was selected for cost comparison purposes and is shown as Figure 5-2. Costs were estimated for controlling one boiler, and for controlling four boilers in reasonably close proximity.

Notes to Figure 5-1

N.A. means "not applicable"

1. Moore Products has digital controllers in development.

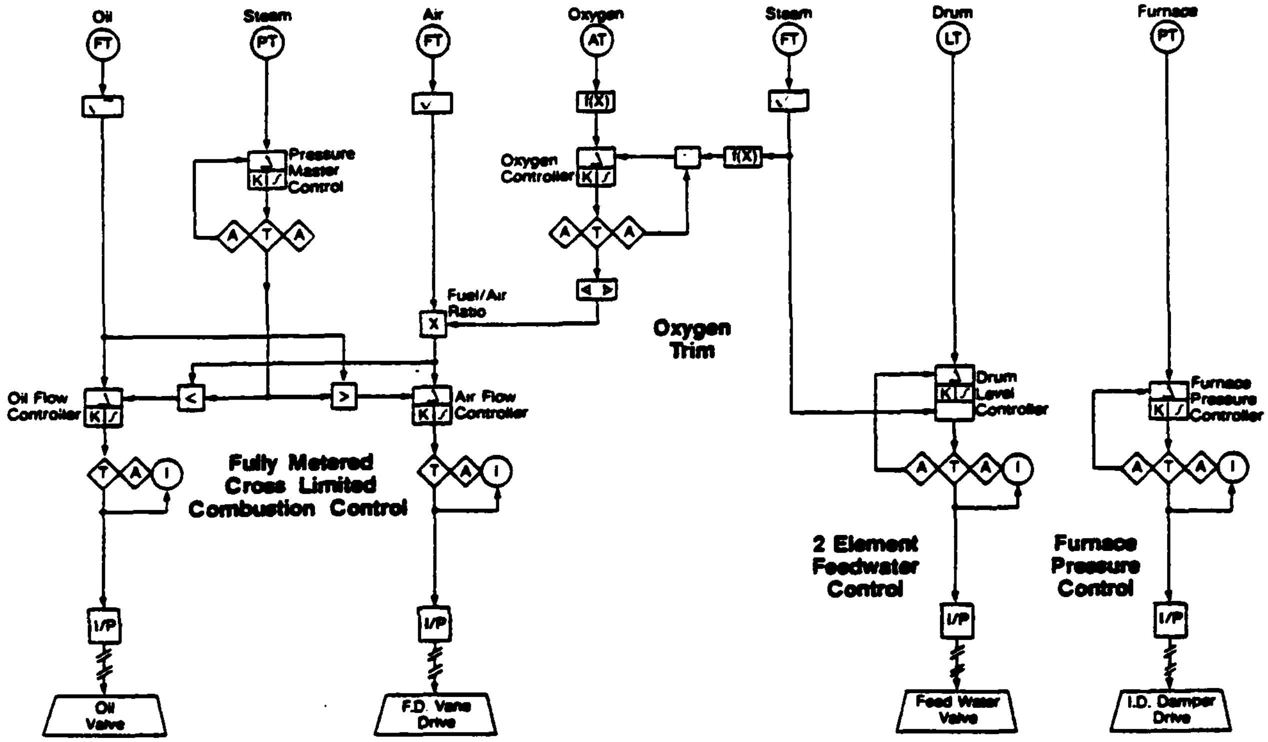

Figure 5–2 – SAMA Logic diagram of boiler control system selected for cost reference.

6.0 COMMENTS ON CONTROL SYSTEMS CONSIDERED

The following comments are intended to be a brief highlighting of the control systems considered in this study. They are presented in the same order as in sections 4 and 5 without ranking. Many characteristics are common to all or most of the systems considered, and are not repeated in the individual system comments. Some of these common characteristics are:

1. Color CRT display-This is available for all systems. Eight colors is the most common.
2. Diagnostic routines-Watch dog timers, check codes, parity and dropout checks, check sums, high level data link control (HDLC) and keyboard response checking.
3. Display types-Typical are overview, group, loops, trend, alarm, graphic and alphanumeric lists.
4. Printers-Logs all alarms, responses to alarms, all operator actions, and loop configurations with tuning parameters.
5. Distributed control-With a few exceptions, all systems utilize functionally distributed control architecture.
6. Maintenance-Most systems indicate trouble areas with diagnostic routines or integral LED indicators so that circuit boards can be replaced to correct the problem. All companies have training capabilities for maintenance people or will provide complete maintenance service.
7. Keyboards-All system have keyboards designed for maximum operator comprehension and convenience. Many of the keyboards have membrane faceplates to prevent damage from fluid spillage.
8. Environmental-All systems require a standard electronics operating environment of approximately 40°F to 120°F temperature and 5% to 95% relative humidity, although closer limits are desirable for normal operation.
9. Power-All systems are designed to operate on dedicated 110 VAC @ $60H_z$, although some have an option for 24 VDC.

10. Ground-All systems require a dedicated ground, but for some systems it is very critical, while others are quite tolerant. This characteristic can have a large bearing on installation costs and should be thoroughly investigated before purchase.

11. Connections-All of these systems come with the internal connections made and short range cabling available, so the only installation connections required are the inputs, outputs, and long haul communication links.

12. Programing-A great deal of effort has been spent on all of these control systems in order to make configuration programing as simple as possible for the power plant engineer by the use of terms and techniques that are familiar to him. Also, all of the manufacturers of these control systems have application and training engineers who will either do all of the system programing for you, or train and assist you to do it.

6.1 <u>Leeds & Northrup - MAX 1</u> (A in chart)

The MAX 1 is a radially connected direct digital distributed control system having 8 loops per controller. A long range communication link (data highway) is available for this system, but is probably not required for the Navy application to small boiler systems. Color CRT displays are available as well as printers, tape configuration recorders or a floppy disc for custom graphics displays.

This system can be configured to give boiler efficiency directly, or can be connected to a plant computer for more extensive energy monitoring and control. The provisions for reliability incorporated into this system have been thoroughly considered and incorporate self diagnostics, uninterrupted automatic control option for either a complete controller or any part thereof, and redundant power supplies and/or data transmission if desired. Forty control algorithms are available for this system including a selection of three different function generators. The price for this system is competitive for both a single boiler system or multiple boilers.

6.2 <u>Fischer & Porter DCI-4000</u> (B in chart)

The DE1-4000 system is a direct digital distributed control system with a great deal of flexibility in its concept and implementation. In a simple basic configuration for controlling a single small heating boiler it would consist of an 8 loop controller connected (600') to a single CRT station with control keyboard. Programing of the software can be done by a teletype, other standard terminal, or a portable unit which Fischer & Porter makes. This unit has a tape recorder which preserves the programmed configuration on tape for future use. There are ample control algorithms available including a six segment function generator.

The operators keyboard of this system is exceptionally well planned and one of its features is that the loop selection keys are arranged directly below the CRT screen so that it is an almost automatic reflex to select the loop you want further information or trend data on.

A communication link (data highway) is also available for greater distances and more complex systems, but it would probably not be

justified for the small boiler application unless there were multiple boilers which were widely separated geographically.

The DCI-4000 system can provide uninterrupted automatic control by using a constantly tracking backup controller which automatically takes over on fault detection in the primary controller.

This system has excellent growth potential in both the software and hardware. It is intermediate in cost between the small special purpose units and the large system in which a communication link is mandatory.

6.3 Westinghouse-Hagan DCS-1700 (C in chart)

The DCS-1700 system is an outstanding system for the control of boilers, as examination of the comparison chart shows, the DCS-1700 has over twice as high a percentage of boiler applications as any of the other systems analyzed. As a matter of fact, the control module can be configured to perform the control functions of the reference boiler control selected as a stand alone unit, or it can be controlled from a CRT-keyboard operators station. Configuration programing can be done locally or from the CRT-keyboard, and a keyswitch is provided on each to prevent unauthorized modifications.

This controller (GPC-1500) is less than 7x9 inches on the panel and yet includes track and hold, bumpless transfer, uninterrupted automatic control option and 55 control algorithms including a 10 segment function generator.

In addition to these capabilities it even includes a special calibrating function for an O_2 trim probe. The only possible area of weakness in this system would be for use in a system requiring a large number of inputs to be monitored and a large number of switch closure outputs. In this case the power of the control capabilities could not be efficiently utilized, however, it is probable that this situation will be improved in the near future. The cost of this system without a CRT is the lowest of those investigated, and with a CRT keyboard station it is among the lowest in cost.

6.4 Rosemount - Diogenes (D in chart)

The Diogenes control system is a direct digital control system that employs a central computer for control and display operation. It has been used on a significant number of boiler control applications with very good results. The use of a central computer allows some integral energy optimization to be performed. Even though this system is not a distributed system, the backup control in the event of a primary control fault is by means of an independent analog controller whose memory is updated once per second. Since this system has been sold for 10 years, the operator interface, the displays (including custom graphics) and the engineering configuration procedures are very well worked out and convenient.

This system has the inherent capability to monitor and alarm a large number of inputs and output a large number of digital outputs in addition to the continuous loop control functions. The cost figures for a single reference boiler control are a little above many of the systems analyzed but for multi boiler installations, i.e., 4 reference boilers, the cost for the Diogenes system is very competitive.

6.5 Beckman - MV-8000 (E in chart)

The MV-8000 control system from Beckman is a "high end" system which utilizes a redundant communication link (data highway or Beckman bus) which allows spacing of up to 5000' between system elements. The single loop controllers used with this system are hybrid analog-digital controllers, but all multi loop controllers are fully digital and incorporate complete functional redundancy for inherent uninterrupted automatic control.

The control algorithms available for this system include a six segment function generator and a mode transfer which allows transfers between continuous control and digital control either way as often as required to implement the desired control functions. The operator station is very well designed with a color CRT, keyboard and separate alarm annunciator panel. In addition to the keyboard, a light pen is included for the operator to directly call up detail displays from the

CRT without using the keyboard. All data is transferred using ASCII/RS232C format, so the use of computers, analyzers or printers by Beckman or others is readily effected.

The cost of this system is high for a single small boiler application, but may be feasible for multiple boiler control from a single operator station.

6.6 Moore Products - Mycro System (F in chart)

The Mycro distributed control system is included in this study, even though the present controllers offered are electronic analog type, because Moore Products has a full digital controller in development. The operator's station and displays are very well thought out for operator and configuration engineer convenience, and this system includes a graphic pad option for custom graphic's display generation. This option is not offered by any of the other control system manufacturers responding to this study, and it appears to simplify the preparation of custom graphic displays using the pads provided for layout and then "tracing" them onto the CRT with the cursor control pen. A redundant communication link is included as well as thorough internal diagnostics. Location of malfunctions is facilitated by an automatic functional diagnostic routine backed up by a more intensive off-line routine which can be initiated by the operator if further problems are suspected.

The cost estimates for this system places it in an intermediate position for both single and multi boiler applications.

6.7 Texas Instruments - PM 550 (G in chart)

The Program Master (PM550) control system is capable of controlling a minimum of 8 loops per control module, and the operator interface can be either a pushbutton station with digital display of the process variable, set point, output and tuning parameters or a CRT-keyboard station. Programing of control algorithms is done by a simple keyboard and digital display unit or the CRT-keyboard station, if included. Sixteen continuous control algorithms are included and they can be "chained" together to perform desired control or data manipulation functions. Significant mathematical operations on the data input can be simply programmed, and this unit will accept BCD data inputs.

The estimated price for this system is among the lowest of the systems examined and more units of this system have been sold than any of the other control systems examined, although this may be misleading as most of the units sold were for use as programable controllers, and not for continuous control.

6.8 Robertshaw - DCS-1000 (H in chart)

The DCS-1000 is a flexible distributed control system based on single loop stand alone intelligent controller modules. These each include an engineering configuration panel on the side of the unit which is available when the unit is slid part way out of its housing. They also include a manual backup station which can be used when the digital unit is removed for service or replacement.

The display options available for the CRT monitor include custom graphics, and an arrangement of so called "virtual firmware" (software) which allows the creation of non-distributed digital control loops within the CRT electronics for the control of non critical loops where lower security can be tolerated. These "virtual firmware" elements include ramps, timers, boolean logic and computational units which may be used alone or linked together.

The DCS-1000 system is in the intermediate price category between the "high end" systems and the least expensive systems. It offers the flexibility of being implemented in a progressive manner, starting with the single loop stand alone controllers on a single boiler, and then adding a CRT operating station when more boilers are added.

6.9 Micon - MDC-200 (I in chart)

The MDC-200 control system is a distributed digital control system based on the Micon P-200 controller, which may be used as a stand alone controller for up to 8 loops. This controller is complete with digital displays, pushbuttons, and an engineers panel on the side for configuration setting. There are 70 control algorithms available in the P-200, any 20 of which may be applied to a specific control loop in any order desired. Security of this system can be insured to any degree desired by means of manual backup stations or a spare controller which can be arranged to provide uninterrupted automatic control for up to 8 controllers (64 loops). It will automatically replace a failed unit including configuration memory transfer in less than 1 second. A CRT operators station may control up to 32 controllers (256 loops) including printers and strip chart recorders. A complete set of CRT displays are available including custom graphics, alarms, loops and trending. For use with the CRT operators station, the controllers may be purchased without the local displays and control buttons, or just without the engineers configuring panel. The cost of this system is in the lower intermediate range and they have significant number of boiler applications in service, so it should receive serious consideration for the Navy small heating boiler application.

6.10 Bristol Babcock - System 3000 (J in chart)

The system 3000 is a distributed digital control system made up of a family of stand alone controllers with capacities of 1 loop, 8 loops or 40-50 loops. A CRT-keyboard operators control and monitoring station is available as are printers, recorders, and backup hardware. Communications are either local or with a long range redundant

communication link, and the security provisions allow a wide choice of arrangements from manual backup to uninterrupted automatic control. A very simple operators keyboard is used with this system and it is augmented with a cursor selection of "poke-points" on the CRT screen for display selection etc. A multi level software security system requires operator log-ons and prevents unauthorized access to selected displays and parameters. Among the software "modules" is a calculator which permits efficiency to be calculated continuously as well as the usual PID controllers, lead-lag, peak detector and function generator. The cost of the system 3000 is surprisingly low, just above the lowest priced systems.

6.11 Bailey - Network 90 (K in chart)

Network 90 is a very flexible distributed digital control system that is applicable across the board from very small single loop controls to the complete control of a large plant. It is a difficult system to discuss because of this flexibility of a large number of possible system arrangements and possibilities. Therefore, the following discussion will only consider the elements of the system which are applicable to small heating boilers, either singly or in groups of a few boilers.

The basic controller module can be configured for one or two loops and includes a comprehensive library of software functions including a function generator, as well as full diagnostic routines. A configuration and timing module in conjunction with controller(s) and a digital control station will make an excellent all digital "bottom end" system. Or a CRT-keyboard operator station can be used with the controller(s) to yield a more sophisticated distributed digital control system. Redundant communications, local and long haul, are offered as well as redundant power supplies and communication termination modules. However, the Network 90 system does not include an uninterrupted automatic control option even though the controllers are designed to be as reliable and "fail safe" as possible.

The cost of the Network 90 system is in the "upper-intermediate" range for small boilers when a CRT is supplied, and among the least expensive when used with a digital control station and no CRT.

6.12 Honeywell - TDC-2000 (L in chart)

The TDC-2000 was one of the first digital process control systems with distributed control logic and centralized monitoring capabilities to achieve wide acceptance. A possible disadvantage of this system for the Navy single small boiler application is that it uses a communication link (data hiway) which is necessary for large geographically dispersed systems, but must make small systems less cost effective than some of the other systems in which a data hiway is not mandatory. This possible disadvantage may not apply for multi-boiler systems. This system offers an uninterrupted automatic control option which is based on one backup controller for up to eight operating controllers and the transfer of control and configuration memory takes place in less than one second. The selection of control algorithms offered does not include a function generator in their basic controllers, however, it is offered in their more expensive enhanced controllers. This may be required for use with some O_2 trim systems. The reliability and security of this system are not only well planned and executed, but the very extensive experience and application of this system has led to outstanding refinement and development. The cost of this system is estimated to be intermediate as applied to the reference boiler control system, and it has many excellent capabilities.

6.13 Foxboro - Spectrum (M in chart)

The Spectrum system is just what the name implies, a broad spectrum of computers, controllers and communications going under the trade names Fox 3, Fox 1A, Foxnet, Videospec, Microspec, Spec 200 and Interspec. Space in this report does not permit a complete delineation of the uses, functions and capabilities of these controls, but it is apparent that systems of very large capability including supervisory computers etc. can be assembled from the elements available from Foxboro.

The security provisions incorporated into this system include redundant power supplies, redundant communications, and an uninterrupted automatic control option. Full internal diagnostics, a watchdog timer, and memory checking are included as well as thorough communication checks. A broad scope of control algorithms is offered including adaptive tuning and output clamping. The supervisory computers offered as part of the Spectrum system can provide report preparation in any format desired as well as energy monitoring and management functions.

The cost of this system is difficult to define due to the many possible ways of arranging it, but on an equal capabilities basis, it is very competitive with the other systems analyzed.

6.14 Gould - Modicon (N in chart)

The Modicon system is a direct digital control system with several features that are unique among the systems surveyed in this study. One is the use of a touch sensitive screen on a bit-mapped color graphics CRT which leads to a very simple operator interface for monitoring and controlling process variables. A menu type of display can present a pictorial representation of the operators choices in a given situation, which he can select by a touch of his finger to the CRT screen. An operator can use this system without any "typing" knowledge whatsoever. The resolution of this touch system is 0.1 inch vertically and horizontally; and it can be used in conjunction with custom graphic displays. Another interesting feature is the function generator which allows 12 bit accuracy (1 part in 4096) in each axis. The system has good computational capability as well as an uninterrupted automatic control option. A standard keyboard is offered as an option for configuring and display programing, but a separate programmer unit with its own small CRT display is also available. It should be pointed out that one programmer can be used to set up many systems, as it is not needed after the system is configured. The estimated prices for this unit are very competitive for both single and multiple boiler applications.

6.15 Measurex - 2002 Energy Master (O in chart)

This system is a computer arranged for direct digital boiler control and energy optimization. It is not a distributed control system and so does not offer the same architectural control security offered by most of the other systems studied, even though a redundant power supply is offered. It is primarily designed to operate with the Measurex $CO-CO_2$ analyzer probe system and to do a somewhat more sophisticated energy optimization than many of the control systems considered in this study.

The fact that it has been applied to a large number of boilers in a short time indicates that it has significant merit in these days of very high fuel costs. The control algorithms (software) available allow for the compensation of imperfect sensor and actuator characteristics in order to achieve the highest possible boiler efficiency.

The cost estimates for this system for either a single boiler, or for four boilers in a shared control arrangement are among the highest of the systems examined. The architecture of this system does not lend itself to the progressive or "stepped" installation approach, but must be effected in a single installation step.

6.16 Fisher - PRŌVOX (P in chart)

This system appears to be very well thought out in that it provides a great deal of flexibility in its application with an architecture that has excellent security considerations. The controllers can be operated from single loop operator display stations or from a central CRT console operators station. Configuration and loop timing are provided by a clever hand held tuner about the size of a pocket calculator which includes a magnetic card encoder/reader for backup storage of the configuration and tuning parameters for each loop. This unit is primarily intended for use with the single loop operator display stations as configuration and timing can be done from the CRT operators console when it is installed.

Redundant power supplies, communications, and controllers are available for uninterrupted automatic control. Thorough self diagnostic routines and alarms are provided, and any circuit board can

be replaced without disturbing any other circuit board or wiring thereto. A good selection of standard predefined displays are available as well as custom graphic displays for which three levels of loop or point data display faceplates can be used.

The estimated costs for this system compare very well for the single reference boiler without CRT and yet the system has economical growth potential to a very large application, i.e., multiple boilers.

7.0 DISCUSSION OF CHARACTERISTICS

The following general discussion of some of the major characteristics of these control systems is presented to give an understanding of the overall considerations for the application of direct digital control to the Navy's small boilers. The assumptions made as to the present controls on these boilers is that they are relatively old and generally not in good repair, and that most of the control mechanization includes only a minimum of flow metering, or none.

7.1 Cost Effectiveness

The cost effectiveness of any of these direct digital control systems is so good compared to the control systems presumed in place on these boilers that there is no question that the return on investment will be very rapid on the basis of fuel cost savings alone. The reason for a fuel cost saving is of course the reduction of excess air which must be heated by burning fuel to the exhaust temperature. An older combustion control system, in poorly maintained condition, must be adjusted to have a large amount of excess air to prevent smoking, while a tight digital system can be adjusted to have a minimum of excess air with good combustion and no smoke. To this saving, the reduced requirements for the operator and lower maintenance expense must be added. It is estimated that a saving in fuel cost of from 2% to 6% can be realized by the control improvement to be realized by the installation of a "tight" control system due to the reduction in excess combustion air that can be realized.

7.2 Reliability and Security

7.2.1 Reliability

Reliability is the most important characteristic of any boiler control system and this is well recognized by all of the system manufacturers listed. It is the primary reason that the "distributed system" approach is used by most of the manufacturers listed, wherein the data base memory used by each loop controller resides in that controller at

all times, although it may be duplicated in other parts of the system. This means that a communication link failure, for instance, will not jeopardize the function of a controller, as would be the case if all data base memory resided in a large central controller or computer. In addition to the distributed system architecture mentioned above, many of the following security and reliability techniques are used in conjunction to provide the utmost control and monitoring system reliability.

7.2.2 Error Check Codes

Each word transmitted on the communication link is checked for data integrity. Each bit must have a positive and a negative pulse, and all bits are counted. A sophisticated error check code is computed by the sending device and included in the word. The error check code is then re-computed by the receiving device. Each data word transmitted is retransmitted (echoed) by the receiving device, and must compare identically. Any discrepancy in any check will cause the word to be rejected, and a notice of the rejection given. If a predetermined error threshold is exceeded, the communication link may be automatically switched to a backup link.

7.2.3 Redundant Communication Links

Most systems include a redundant communication link which has its cables routed separately to preclude loss of both the primary and backup link in case of an accident. Most communication links also include isolation couplings at each connected element to prevent damage to the link in case of element failure.

7.2.4 Diagnostic Routines

The controllers generally incorporate diagnostic routines to self test several times a second. The following items are checked; Power regulator, analog/digital and digital/analog conversions at high and low limits, output, CPU miscellaneous errors, memory and instruction set check. Diagnostic routines are also programmed to check the communication link and all connected elements by means of exerciser and watchdog techniques.

7.2.5 Redundant Memory

A backup non volatile RAM memory that is constantly updated during normal operation with all pertinent process data, both configured and process derived, is often included in the controller. This permits error diagnostics as well as allowing restart after a power loss or equipment failure.

7.2.6 Battery Backup

A battery backup system is either included or provided as an option for these systems. These battery backups are generally sized to allow at least 30 minutes of operation in which to checkout the loss of power and to permit an orderly shutdown if it is required.

7.2.7 Gradual Degradation

Programing is utilized to insure that progressive failures will cause gradual degradation of control performance rather than a catastrophic "hard over" error. One manufacturer calls this "gracefull degradation". Most systems employ tracking of the Process Variable signal to insure "bumpless" transfer between automatic and manual control, etc.

7.2.8 Uninterrupted Automatic Control

This involves a spare controller which is caused to automatically substitute for a failed controller, notify the operator and switch in a reserve data file if needed. The foregoing takes place in less than one second, regardless of the complexity of the control strategy of the failed controller, and the operator can monitor and manipulate the same loops exactly as he did before the failure. One spare controller can serve as backup for several controllers, so the substitution is not on a one for one basis.

Another approach to uninterrupted automatic control which is available is a system involving a completely redundant controller having full memory, configuration, diagnostics, etc. which is tracking the live controller at all times and ready to take over at any time that the diagnostic programs in the live controller indicate that it is not operating properly. It should be understood that both of the above approaches to uninterrupted automatic control are expensive options and not necessary for reliable control in most applications.

The control systems considered in this study are all from knowledgeable and experienced manufacturers who have made the reliability and security of these systems the most important design consideration. Many of the techniques used to insure the highest possible system security were discussed in the previous section, and were primarily architectural design considerations. In addition to these system considerations, reliability of the electronic components is enhanced by a "burn-in" for many hours at high temperature and high power. This serves to move them out on the failure history curve to past the initial failure region to where they are very reliable, especially when operated at the conservative power levels where the components of these systems are designed to operate.

There are many cost vs. reliability/security tradeoffs which must be made when defining a digital boiler control system, for instance, many of the systems studied offer an "uninterrupted automatic control option" which will automatically switch control to a backup digital controller automatically and tell the operator that this has been done in the case of a controller failure. The process being controlled will not be aware that anything has happened. This is very nice, but also adds to he cost, and may not be justified for these small boiler systems where a transfer to manual control may be completely acceptable. However, in some systems it is possible to add this capability in the future if desired, and this possibility may add very little or nothing to the initial cost, so should be carefully considered. There are many other areas like this that should be looked at before a system is defined.

7.3 Refit Installations

Refit capabilities are inherent in all of the systems examined in this study, and many of them are specifically designed so that this can be effected in stages as funds become available. A hypothetical case will serve to illustrate how this might be accomplished for a boiler with old worn out controllers but with some good transmitters (sensors) and valve/damper operators. It could be done in the following steps:

Step 1.

Replace controllers with single or multi loop digital controllers, add flowmeters as required, replace bad transmitters, replace bad valve/damper operators and install pneumatic/electronic relays on good transmitters and valve operators.

Step 2.

Add O_2 trim system.

Step 3.

Add CRT-keyboard operators station.

Step 4.

Replace all remaining transmitters (sensors) and valve/damper operators.

Step 5.

Add tie-in to supervisory computer.

Step 6.

Add more boilers to system on same basis.

7.4 Mechanical/Electrical Interface Requirements

Typical mechanical configuration of these systems would have the controllers mounted in standard 19" relay racks, and the operators station CRT-keyboard is available in a rack mounted version, or a built in desk mount for most of the systems examined.

The electrical power requirements are typically 117 VAC±8% 50/60 Hz, and several systems will operate on 24 VDC±8% as an option. The total power required for these systems will not exceed 1000 watts per boiler. The electrical input/output interfaces are brought out to integral termination panels.

7.5 Sensors

All systems investigated will accept digital, analog, or even pneumatic (with adapter relay) sensor inputs. Thus, they can be used with existing good sensors temporarily, and later switched to new sensors.

7.6 Backup Control Requirements

These system typically have track and hold on outputs so can provide "bumpless" transfer to backup controls which can be either:

a. An existing control system if in good operating condition.
b. Manual backup stations with indicators.
c. Uninterrupted automatic control. This extra cost option for many systems provides transfer to a spare controller without the process being aware that it has taken place. It increases the cost significantly.

The practical choice for the Navy small boiler requirement is probably b. above.

7.7 Compatibility With Current Operating Practices

All of the systems examined in this study are designed to be as compatible as possible with current operating practices so as to require a minimum of operator and engineer orientation and training. Thus, the CRT display of a single loop or group of loops simulates the face of a standard pneumatic or electric analog controller. Similarly, the keyboards have been planned with a great deal of ingenuity to make them as simple and easy for the operator to understand as possible. Even the engineering configuration of most of these control systems can be performed without computer programing knowledge, but with just inputs to a "menu" which leads the engineer through the steps required in simple english.

7.8 Use With Energy Monitoring and Control Systems (EMCS)

All of the systems examined in this study have the capability of connection to a computer for EMCS, and in addition to this, several of the systems have the capability of performing some level of EMCS with no, or very minimal, additional equipment.

DRAFT MILITARY GUIDELINE

SPECIFICATION

for

DIGITAL BOILER CONTROL and MONITORING SYSTEM

Prepared by: Ultrasystems, Inc.

Prepared for: DEPARTMENT OF THE NAVY
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SPECIFICATION FOR

DIGITAL BOILER CONTROL AND MONITORING SYSTEM

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1.0 GENERAL

This specification delineates the requirements of a digital boiler and monitoring system. Hereafter the supplier of the equipment covered by this specification shall be referred to as the Seller, and the issuing party of this specification as the Buyer.

The Control & Monitoring System covered by this specification shall be based upon the use of a microprocessor-controlled operator's console and CRT (Cathode Ray Tube) displays. The operator's console, through a data link, displays information from the controller portion of the system, and provides an operator interface to the process. Performance requirements are contained in Section 2.0 following.

The operation of the system covered by this specification shall be such that an individual familiar with conventional analog type instrumentation will be capable of operating the proposed system with a minimum of training. The system shall not require knowledge of any computer electronics, or a computer language not specifically designed for process control.

Any omissions of details in this specification shall not relieve the Seller of his obligation to furnish a system which is complete, and which operates in a satisfactory manner. All detailed information necessary will be supplied to the Seller. The Seller shall be responsible for contacting the Buyer if information found to be required has not been supplied.

This document defines the minimum performance levels required of the system. Alternate system features may be proposed by the Seller.

The components and accessories furnished hereunder shall be designed and fabricated in accordance with the Codes and Standards listed in Section II, and any local codes or standards, listed or not, having jurisdiction over the equipment being supplied.

All dimensions on required drawings are to be in English Units.

The Seller shall furnish the control consoles, process interface units (if required), the controllers, termination cabinets and peripherals ready for installation with all work completed.

1.1 CODES AND STANDARDS

Unless otherwise stated herein the equipment supplied under this specification shall be designed, manufactured, and tested according to the latest applicable provisions of the following standards:

NEMA - National Electrical Manufacturer's Association
IEEE - Institute of Electrical and Electronic Engineers
OSHA - Occupational Safety and Health Administration
ISA - Instrument Society of America

2.0 PERFORMANCE

2.1 GENERAL

The Control System supplied under this specification shall be capable of performing all control and operator/process interface tasks normally associated with conventional main control room control panels.

The design shall be such that failure of any portion shall have a minimal effect on the process. Thus

A.

B.

etc.

The specific tasks include, but are not limited to:

A.

B.

etc.

2.2 SYSTEM ARCHITECTURE

The system shall consist of the following major functional devices or subsystems:

2.2.1 OPERATOR'S CONSOLE

The CRT-based console will be located in the central control room and shall consist of:

A.

B.

etc.

2.2.2 PROCESS INTERFACE UNITS

The process interface units (if required) shall contain the following:

A.

B.

etc.

2.2.3 TERMINATION CABINETS

The termination cabinets shall contain:

A.

B.

etc.

2.2.4 INTERCONNECTING CABLES, PREFABRICATED

The Seller shall provide prefabricated cables, with connectors on both ends, for the following:

A.

B.

etc.

3.0 FUNCTIONAL REQUIREMENTS

The functions defined below are the minimum capabilities required. No tabulation shall be considered to exclude others available from the Seller. The Seller shall submit a definition of the manner in which each is met, and shall include a statement of alternate or optional features.

3.1 CONTROLLERS

Microprocessor-based process controllers shall be supplied. It shall be possible to program these devices to include at least the following or similar functions in any rational combination:

A.

B.

etc.

3.2 ALARM FUNCTIONS

The Control System shall be capable of alerting the operator of abnormal process conditions or internal control system faults.

Alarm annunciation and display groups shall include designated alarms from any of the following:

- Open or closed field contacts
- High and high-high or low and low-low analog inputs
- High or low controller deviation (Adjustable)
- Alarm settings for input, output or deviation alarms shall be set from the operator's console

Once the display in alarm has been accessed, the operator shall acknowledge the alarm by depressing an acknowledge key. Alarms shall not be automatically acknowledged by access of the display alone.

3.3 CRT DISPLAYS

This section defines the minimum information which shall be available on the console CRT displays.
Seller shall provide photographs or drawings of each type of display with the bid. Drawings or photographs are required for each state of a display (i.e. normal, alarm, acknowledged alarm).

The system shall have full flexibility in specifying or changing the numbers, descriptions, ranges, scale factors, or grouping in the various displays.

Each display shall always provide the following:

- o Time of day in hours and minutes
- o Date by month and day
- o Page number

3.3.1 OVERVIEW DISPLAY

3.3.2 GROUP DISPLAY

3.3.3 INDIVIDUAL LOOP DISPLAY

3.3.4 ALARM DISPLAY

3.3.5 INTERACTIVE GRAPHIC DISPLAY OPTION

3.4 ALARM/LOGGING PRINTER OPTION

The system printer shall printout all alarms and their return to normal. The alarm printout shall at least include the date and time to the nearest minute, the tag number, and the value of the variable which caused the alarm, in engineering units. The return to normal printout shall show the same data, with the addition of a notation indicating safe operation.

The machine shall be capable of printing a summary of all points still in alarm every fifteen minutes. The summary shall start with a heading showing date and time, and repeat of each alarm printout.

Operator changes, such as a new set-point entry, shall be logged similar to alarm occurrence logging.

3.5 REPORT PRINTER OPTION

The report printer shall be identical to and interchangeable with the Alarm/Logging Printer. This printer shall printout shift, daily, monthly, logs and summary logs. The log formats shall be flexible,

allowing the Buyer a format to meet specific record requirements. In the event one of the two printers fails, all information shall be temporarily logged on the operating printer. With one printer in operation summary logs shall not be interrupted by events. Events shall be retained in memory and printed out immediately following the completion of the summary log. Alarms shall be immediately displayed on the CRT although their printing may be temporarily inhibited.

3.6 SYSTEM CONFIGURATION DISPLAYS

The control system shall be capable of displays which provide information about the data communications channel and display configurations. Desirable displays are:

A.

B.

etc.

3.7 SYSTEM DIAGNOSTIC DISPLAY

A display shall be available which shows the status of each unit connected to the CRT. Units in which a failure has been detected shall be indicated by red or other visible display indication, and a code indicating the type of failure detected.

3.8 TRENDING

Any analog variable connected to the system shall be capable of trending. The time base for each trend shall be independent and operator selectable. The trends shall be displayed on the CRT by operator selection.

3.9 HISTORICAL TRENDING

The system shall be capable of trend recording on variable time bases. The system shall have a capacity of at least 32 process or calculated variables assignable to trending.

3.10 MOTOR CONTROL

The system shall be capable of providing parallel/series stop-start functions for input to the Buyers relay control system. The Buyer's relays will provide contact inputs to the system for alarm and status indication.

Seller's system shall be capable of full sequential and logic control with status and security checking, of all logic functions associated with motor and on-off valve control.

3.11 COMPUTER INTERFACE OPTION

The system shall include a data bus interface to connect the system data bus to the Buyer's remote data aquisition computer.

3.12 SYSTEM SECURITY

The control system shall be equipped with a key-lock system which prevents unauthorized personnel from:

- o Changing controller tuning parameters
- o Changing contents of system displays
- o Changing controller configuration data
- o Changing alarm settings

The key-lock system shall not interfere with normal operator tasks such as manually manipulating controller outputs and set points.

The operator's station system configuration shall have key-locks.

4.0 ELECTRICAL SYSTEMS

4.1 A.C. MAIN SUPPLY

The control system shall use 120 or 230 volt, 60 Hz. with ± 10% voltage fluctuations as a primary power feed.

4.2 UNINTERRUPTABLE POWER SUPPLY OPTION

A 30 minute U.P.S. shall be furnished. This power source shall be designed to be in continuous operation with gel-cell batteries "floating" on the D.C. bus to the inverter. In the event of failure of the AC mains, the batteries will supply power to the inverter with no need to switch any portion of the U.P.S. Sensing the failure of the AC mains shall initiate an alarm.

Seller shall submit a price deduction for a 15 minute U.P.S. option.

4.3 POWER SUPPLIES

Seller shall provide all power supplies and internal power wiring.

Seller will provide circuit breakers and circuit breaker boxes for consoles and racks as required. Seller shall provide junction boxes and distribution wiring for primary power.

The Seller shall provide a duplex convenience outlet (straight plate) rated at 120 Vac, 15 Amps for each cabinet unit and each operator console. Wiring shall be separate from the U.P.S. source.

Internal power wiring such as wiring from junction boxes to power supplies or fans shall be run in separate raceways and physically isolated from signal wiring and electronic equipment.

As an option, Seller shall quote a system of redundant power supplies.

4.4 GROUNDING

Seller shall specify requirements for power and signal grounding.

Racks shall be equipped with a ¼" X 1" copper ground bus extending its entire length with the panel structure connected to the bus so as to effectively ground the entire structure. A solderless compression type terminal lug shall be provided at each end of the ground bus for Buyer's #2/0 AWG stranded ground cable.

4.5 WIRING

All field wiring will be terminated on Field Terminal Blocks (FTB's) located in the termination cabinets. All wiring shall enter these cabinets from the top.

Seller shall wire from the Field Terminal Blocks to his standard termination devices.
All wiring shall be permanently tagged with the loop designation shown on the Buyer's Loop Diagram with sleeve type markers. Markers shall be black letters on white sleeves.
Seller shall provide suitable wireways for all internal signal wiring and for all field wiring entering the Control System equipment cabinets. Wireways shall be Panduit or equal. Wireways shall not be filled any more than 60% of capacity.

Instrumentation wiring shall be twisted pairs with a minimum wire size of #18 AWG stranded. Insulation shall be PVC, rated at 600 volts.

Wiring for systems requiring 120 Vac shall be type SIS, G.E. Vulkene or approved equal, insulated for 600 volts; minimum wire size shall be #14 AWG stranded unless otherwise specified.

All exposed wiring shall be formed neatly with square corners, and where possible, grouped in packs. Each pack shall be bound with plastic ties and shall be substantially supported throughout its full length.

Splicing of wires is not permitted.

5.0 SYSTEM DIAGNOSTICS

The Control System shall continuously monitor itself for failures of its various components and provide a means of advising the operator when a failure is detected.

A failure in a controller unit shall also be indicated at the operator's console by a light and type of error code or other equivalent representation.

6.0 TESTING AND INSPECTION

The entire Control System shall be given a complete shop test prior to shipment. Complete system staging shall be accomplished at one factory location.

All electronic components and circuit boards shall be tested and burned-in before installation at Seller's facility.

6.0 FACTORY TESTS

Prior to shipment, the Seller shall connect all system components to a data channel and test the operation of the operator's console, controllers displays, printers and all other peripherals.

Seller shall perform a complete system functional test before advising the Buyer that the system is available for a witnessed test. However, Buyer may elect to participate in system de-bugging.

Seller shall advise Buyer that system is ready for a witnessed test at least two weeks in advance. (De-bugging or functional testing).

At least 30 days prior to scheduled completion of the system, Seller shall forward to Buyer an outline of proposed tests. The Buyer reserves the right to make such changes in the procedure that will result in more detailed or thorough testing. Once mutually agreed upon and approved, the outline will serve as primary test document, and all tests indicated will be conducted and witnessed.
Witnessed tests shall consist of at least a functional test of each input point, output point, alarm point, and control loop, supervisory computer, programmable controllers and system peripherals for proper function and proper display at the operator's console. Tests will be performed using simulated inputs.

The Buyer shall assign representatives to witness the above tests. These representatives shall also assist the de-bugging of controller and display configurations.

Seller shall provide Buyers' representatives necessary facilities, personnel, and test equipment to perform witnessed tests.

Once the system and display configurations have been accepted, the Seller shall make Two (2) "as built" hard copies of the configuration data from the configuration displays and also make a record of the configuration on a cassette tape or diskette. This stored data will be used to reconfigure the system after installation.

6.2 FIELD TESTS

After installation of the system, a field test shall be done to verify the proper operation of the system. Any field changes shall be reported with all documentation updated.

The Seller shall provide necessary personnel to supervise initial power-up of the system and to perform a complete functional test. Additionally, Seller's personnel shall be present during plant start-up, if requested by the Buyer. Continuity of Seller's start-up personnel is required. Daily and summary start-up reports are also required.

7.0 DOCUMENTATION

The following are minimum requirements for documentation:

A.

B.

etc.

8.0 TRAINING

The Seller shall quote costs for complete training of the Owner's personnel in the operation and maintenance of the system.

9.0 INSTALLATION AND TAGGING

System is to be composed of pre-assembled modules complete with power supplies, functional equipment, ventilation fans as required and internal power and signal wiring.

All operator's consoles, cabinets and equipment mounted within shall be tagged with engraved laminated plastic tags.

Tags shall be 3 ply laminated plastic with black face and white letters. Nameplate size, wording, letter size style shall be as specified by the Buyer.

Tags shall be attached with rivets or screws to the equipment in a visible area.

10.0 SHIPPING

After acceptance of shop test by Buyer, Seller shall disconnect all equipment and prepare the system for shipment.

All interconnecting cables are to be labeled at each end specifying cabinet, terminal panel and plug-in receptable to which cable is to be reconnected.

Shipment shall be by air ride van, which shall include heavy shockmounts and G-force recorders for 3 axes.

The Buyer shall be advised of the scheduled shipping date at least two weeks in advance.

11.0 MAINTENANCE AND SUPPORT - POST START UP

Seller shall describe their capabilities in supporting plant maintenance needs for the following:

- o Field representatives
- o Spare part stocking; local or on-site
- o 24 hour notice for service

Seller shall completely support documentation supplied with system. Factory documentation updates and addenda shall be provided immediately upon their release.

12.0 PRE-AWARD PRESENTATION

Buyer may elect to hold a pre-aware presentation at Buyer's premises for the purpose of discussing the quotation, compliance with the specifications here-in, and resolution of misunderstandings or ambiguities. Seller shall be notified ten (10) calendar days in advance.

APPENDIX A

GLOSSARY OF TERMS AND ABBREVIATIONS

TERM	DEFINITION
	A
A Equation	A configuration option of the three mode control algorithm that provides control adjustment as a function of error for a change in either the process variable or set point.
Alarm Equation	The occurrence, acknowledgement, and return to normal of process alarm.
Alarm Group	A display that shows the alarm condition for all points within a given Alarm Group. Each Alarm Group typically represents a particular process area or operating section of the plant.
Alarm Limit	The boundary point at which an abnormal or out of limits condition is indicated.
Alarm Scan	An interrogation sent to devices on the communication link to determine their alarm status.
Alarm Summary	An alarm display that provides an overview display of a series of activated alarms accompanied by pertinent data related to each point tag name.
Alarm Type	A general classification of the alarm condition. For example, out of limits alarms (indicated in engineering units) or deviation alarms (indicated in percent) result when process limits are exceeded.
Algorithm	A set of rules defining the steps to be taken, for example in determining a control action. Control algorithms activate control functions. Auxiliary algorithms provide signal monitoring, computational, and signal conditioning functions.

Allocation	The assignment of data blocks to specified storage locations.
Analog Calibrator	Portable, self-contained tester for the analog components. Used in conjunction with a program card, it has the ability to perform calibration or testing on auxiliaries, controller files, recorders, analog displays, and standard cables.
Analog Displays	A family of equipment that provides indication of the process variable, set point selection, output manipulation, alarm status, and loop identification information.
Analog Point	A user defined process variable which can take on continuous values representing a process condition such as flow, temperature, or pressure. 2. An individual hardware connection to monitor or control the process.
Analog Restoration	The technique of sending digitized process variable information stored in various devices, across the communication link to the control center, and restoring the process variable value to an equivalent electrical signal.
Analog-To-Digital Conversion (A/D or ADC)	Production of a digital output, representative of an equivalent analog-input value.
Analog Unit	A device on the communication link which provides analog inputs and outputs for use by either a process computer or an Operation Station.
Assignment Display	A display that provides a means to initiate on-line operational functions such as date setting, alarm scanning, clock adjustment, etc.
Auto Reboot	Part of an automatic restart routine which transfers a small program (bootstrap) from mass memory (typically) to main memory. When the bootstrap program is executed, it will transfer appropriate routines to main memory for execution.

Automatic Restart	Circuitry which restarts the equipment after ac power has failed and then resumes. It is sometimes conditional upon the length of the power outage.
Automatic Test Equipment (ATE)	A computer controlled system used to checkout electronic boards.
Auxiliaries	A family of analog circuit cards that perform an array of computational and/or signal conditioning functions on input signals. Typical of these circuit cards are MV/I converters, integrators, alarms, square root extraction, scale and bias, and signal isolators.

B

Backup	A provision for alternate means of operation in case of primary system failure.
Barrier Panel	An assembly which contains zener barriers and is used to limit power transfer between input and output sides of the barriers.
Barrier (Zener)	Used with electronic process control instrumentation where explosive, hazardous atmospheres exist to ensure safe operations. These devices separate the safe area from the hazardous area. Electrical energy is maintained at such low levels that ignition of the hazardous atmosphere cannot occur.
Basic Controller	A microprocessor based device. It measures the values of process variables and applies correction signals according to a control algorithm. The correction signals attempt to hold the process variable at a desired reference setting. Also, the device provides alarm outputs, square root linearization, and creates a corresponding data base by using the appropriate hardware, firmware, etc.
Basic Station	Communication link based, stand-alone microprocessor-driven operator interface consisting of video monitor, keyboard, electronics package, and a cassette transport.
Basic System	The system consists of Basic Stations and Basic Controllers plus other analog and digital devices. System modules are

distributed throughout the process where they monitor and control various functions. A Basic Station communicates with the distributed control modules to sample current values, or status or to redefine system paramaters.

Battery Back-up Unit	A unit that provides supplemental dc power from a battery in the event of ac or dc power losses.
B Equation	A control algorithm in which the error caused by a change in set point provides only integral action to recognize the change.
Binary Search	An algorithm for searching an ordered table to find a particular item.
Block	A group of words or characters considered or transported as a unit, particularly with reference to input and output. The term is used sometimes a a synonym for record, or to refer to a group of records. 2., To collect an assembly of data for some purpose.
Bootload	The act of using the bootstrap load routine. Also, sometimes, the additional step of loading the main system program (hence the term "re-booting" the system).
Bootstrap	A short sequence of instructions, which when entered into the computer's programmable memory will cause another device to load the programmable memory with a larger more sophisticated program, usually a loader program.
Box Address	Unique communication link number assigned to each device interfacing with the Data Highway.
Branch	Software. A logical path in a program.

C

Cable (50-Conductor)	Standard wiring method used to interconnect devices. Each cable contains 25 twisted wire pairs and varies only in length.
Cable (Coaxial)	A central wire surrounded by a cylinder-like shield of braided wires or metal to inhibit noise pickup and maintain uniform transmission characteristics.

Calling Sequence	A sequence of instructions and paramaters used to enter a subroutine. The subroutine uses these entry paramaters in performing some action (e.g., to print, to input data, etc.)
Call-Up	Command to a communication link device that previously responded to a Poll. The call-up command specifically addresses the device and permits it to send a message on the communication link.
Cascade Control	A control strategy in which the output of one controller is the input to another.
Closed Loop	Pertaining to a system with feedback type of control, such that the output is used to modify the input.
Command Word	A message transferred over the communication link that identifies the operation to be performed, the device which is to perform the operation, the address of the sender and sometimes other information.
Communication Link	The data bus connecting all control elements operator stations, etc., in a system. Often called "Data Highway", "Data Bus", or Company designations like "Foxnet", etc.
Communication Link Status Display	A display describing the operational condition of the boxes connected to the communication link. Information shown on the display indicates the address, type of equipment, and status for each unit on the link.
Computational Slot	One of a number user-accessible processing blocks within the Basic Controller. Each can be used to solve any of the auxiliary and control algorithms.
Configuration	-Device. The selection, arrangement, and implementation of parameters associated with a particular device or its points so as to accomplish a control and/or monitoring task. -Hardware. The selection and arrangement of devices needed to implement a particular control system.
Configuration Word	Numerical information that is inserted into the data base of process control devices.

	This information could define operational paramaters, control functions or alarm limits associated with a particular part of the system.
Controller	An assembly that converts instructions, usually in command form, into an ordered arrangement of pulses or voltage levels so as to output information to, or to retrieve information from the controlled device.
Custom Display	A display designed and configured by the user. It can be a schematic, a set of emergency instructions, etc.

D

Daisy Chain	A bus connection between units such that signals pass from one unit to the next.
Data Acquisition System	A centralized monitoring system, which receives signals from multiple remote points.
Data Base (Distributed)	Physical distribution of digital memory throughout the system architecture. All data pertinent to the functioning of each device is stored within itself; however, when necessary, it is available via the communication link to higher level devices requiring that data.
Data Configuration Display	A display that permits the operator to choose one of several other types of displays, especially during the configuration process. Typical choices might be the Tag Name Display, the Library Display, etc.
Data Entry Unit	An operator interface device. It allows the operator to configure slots in the Controller and to observe a limited number of process values.
Data Logger	A printer used to record information with respect to time-especially alarms and the return to normal; tabular logs of calculated averages or instantaneous readings; periodic reports of integrated or computed values, such as the total flows in and out of a unit.
Data Word	A message over the communication link which contains the raw information required by a

	preceding command word. (see Command Word, also Word).
Deadband	An area or zone around a central point of operation (e.g., a setpoint) within which variation is allowed without any correction signal being produced.
Default	Configuration condition which exists when an entry isn't made during the configuration process.
Derivative Action (Rate)	Process control action in which the output is proportional to the rate of input change.
Descriptor Word	Supplementary operator information displayed on the video display for each point.
Detail Display	A display showing a single point-tag name with its associated tuning constants, operational values, configuration data, and other pertinent parameters.
Deviation	The error or difference between the instantaneous value of the controlled variable and the setpoint.
Deviation Alarm	An alarm caused by a variable departing from its desired value by a specific amount.
Deviation-Group Display	A display showing the deviation of the points assigned to a group.
Digital Filter	A software technique used to eliminate undesired or irrelevant data.
Digital Point	A user defined process variable that represents a device which has on/off or open/closed states (e.g., a switch) 2., An individual hardware connection to monitor or control the process via relays, pulses or logic levels.
Direct Digital Control	A mode of control whereby a digital (DDC) computer's outputs are used to directly control a process.
Display	A visual presentation of information. 2., A video monitor device.
Distributed Architecture	Partitioning of the total control task among independent devices. The distributed control devices may communicate through the Data Hiway.

Distributed Processing	A monitoring and control concept in which arithmetic and logical operations are performed by computing elements at remote points, under the coordination of a central control device.
Disturbance	An undesired change in a monitored variable which therefore tends to adversely affect a control output.
Down Line Loading	Loading of a device on the communication link with configuration data from the computer.
Driver	A program that controls external devices or executes other programs.

E

Echo	Communication technique assuring that a word received at the termination point in a system is the same as the word originally transmitted. The received word is re-transmitted to the sending device and matched to ensure that the original message was received properly.
Engineering Units	Standard units of measure applied to a process variable (e.g., PSI, Degrees C, etc.).
Error Detection	A method of processing data such that if transmission or processing errors occur, false results will be discovered.
Exerciser Module	A type of test program used in Supervisory/Total systems to check for interaction between parts of the system. Usually, several exerciser modules (programs) are run together (under control or an executive program) as a system test.

F

File (Hardware)	An enclosure which holds electronic cards and aligns them with electrical connectors.
File (Software)	A collection of records or other information organized toward some purpose.
Fixed Output	An output from a computational slot configured for a signal conditioning algorithm such as a summer or divider. The output of the specified slot is a

	predetermined value based upon the input values.
Floating Output	An output from a computational slot configured for a PID algorithm whose output is not always a predetermined value based upon the input values.

G

Graceful Degradation	A characteristic of some control systems that provides partial rather than total loss of control capability when one or more parts fail.
Ground-Lightning	A ground system that safely dissipates lighting energy to protect personnel and the structure. Lightning energy is intercepted by lightning rods and/or the building frame and conducted to ground rods or a grid.
Ground-Master Reference (Signal Common)	The ground reference point for all signals. All common leads terminate at this point.
Group Display	A display showing up to eight digital and/or analog points. These points are typically associated with one process unit and provide the required operator interface information.
Group Number	A numerical identification associated with a particular display group. Group numbers are found on the overview and Group displays.
Group Title	Descriptive name assigned to each group display.
Group Title Summary	A display that presents a list of the assigned group titles and their associated group numbers in the system.

H

Handshaking	The exchange of predetermined signals between devices of parts of a device when a connection is established or when data is sent or received.
Hardwired	Connection by wires or printed wiring.

High Level	A term which is used with equipment intended for 4-20 mA or 1-5 Volt analog signals. Digital input sense power may be up to 125 V.
Historical Trend trend data Display	Graphic display or print-out of historical for process variables associated with a particular group.

I

Indirect Address	An address specifying a storage location, which in turn contains either a direct or another indirect address.
Initialization	The setting of various counters, switches and addresses to zero, or other starting values, 2., Automatic balancing of computational slot outputs and set point inputs in cascade loops during manual mode to ensure bumpless transfer to full automatic or cascade mode.
Instrumentation	The application of devices for measuring, recording, and/or controlling physical properties and movements.
Integral Control	Action which produces a corrective signal proportional to time integral of the signal. Also known as reset action.
Integrity Card	A printed circuit card used in trouble-shooting to check for damaging or improper voltages before replacing a defective board with a new one.
Intelligent	A device that can perform specific logical or sequential functions as a stand-alone unit using its own processor, instruction set and memory.
Intrinsic Safety	A protective technique that uses equipment and wiring which are incapable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture.

J

Junction Panel	Connector device used to connect and distribute wiring throughout the system.

K

Keyboard — An interface device containing an assortment of lights and push buttons used during set-up time for system definition and to implement various control strategies.

Keylock — A type of lock on the equipment entry consoles and panels to prevent unauthorized personnel from making entries into the operating system.

L

Library — A group of appropriate terms assigned by the user and held in memory for use in building video displays or defining point related data. 2., A collection of proven software routines.

Linearization — Conversion of non-linear measurements into proportional linear engineering units (e.g., PSI, degrees C, etc.). Square root extraction of a differential transmitter signal to obtain flow value is typical.

Local Reference Bar — Copper bus bar that acts as a signal reference point.

Log — A periodic printed summary of operating data.

Loop — A set of instructions repeatedly executed by a processor until some control mechanism allows an exit from the loop; 2. A process control method whereby significant undesired changes in the process causes corrective signals which either adjust the process or alert an operator to do so.

Loop Manual Mode — Manual control of the output from the Analog Display.

M

Marshalling — The gathering of circuits into a methodical arrangement. A single panel may be used to organize the circuits in a local area or they may be channeled through a multi-conductor cable to other terminal panels in a distant area.

Manual Backup	A method of control in which final control elements are adjusted manually in the event of a primary system failure.
Media	Recording devices from which data is read or to which data is written, e.g., magnetic tape, a spinning disc, etc. Medium is the singular form.
Monitor	To observe or supervise the operation of a system; 2. A software executive program which oversees system operation; 3. A video display device.
Mother Board	A main assembly board which contains plugs or sockets where, usually smaller, usually less complex boards called "daughter boards" are connected. Printed wire backplanes are also sometimes considered mother boards.

O

Off-Line	Using software and hardware in an operational mode such that the system isn't actively monitoring or controlling the process.
On-Line	Using software and hardware in an operational mode such that the system is actively monitoring or controlling the process.
Open Loop	A control system that requires operator action to complete the loop (e.g., a device might monitor the process and display the results to an operator who then makes corrective adjustments). 2. A control method having no feedback or feed forward.
Operating Center	Consoles used by the operator as the man-machine interface to the process.
Operating System	Software which controls the execution of computer programs and which may provide scheduling, debugging, input/output control, accounting, compilation, storage assignment, data management, and related services. 2., The executive, utility programs, interrupt service routines, I/O programs, and user-visible, non-hardware facilities.
Operator Station	A general term applied to the keyboard/video display consoles and supporting elements found in operating center.

Operation by Exception	Method of presenting information to the operator or to the computer so that attention is drawn only to points deviating from normal.
Optimize	To establish control parameters which maximize or minimize the value of a performance index.
Output Limits	Boundary points which limit the output.
Output Signal	A signal sent from a device, element, or system.
Overview Display	A display that summarizes the operation of several control groups to show deviations from set points, alarms, etc.
Overview Scaling Index	A means of scaling the maximum permissible deviation from the normal operating point, as viewed on the overview display, before setting a group alarm.

P

Page Addressing	A storage addressing technique in which memory is divided into segments or pages, each of which can be addressed individually.
Parallel Communication	Transmission of data simultaneously on separate lines to speed up operation (as opposed to serial communication).
PID Algorithm	Proportional, Integral, and Derivative control action.
Point	See Analog Point or Digital Point.
Point Display	A display showing tag name and PV magnitude expressed in engineering units of a selected point.
Point Group Summary	A display that presents a list of all point tag names and their assignment to operating groups and alarm groups.
Point ID	An alphanumeric designation of a point used by the system to identify each point in the process.
Point Tag Configuration	A procedure which allows the user to define various parameters associated with a point

tag name, and to activate the point in the system.

Poll	In general, any process used to interrogate individual remote devices in a network so as to determine if service is required.
Power Junction Assembly	A device which serves as distribution point from power supplies to one or more bus bars which comprise a branch power circuit.
Preferred Access Device	An intelligent stand alone device that is capable of requesting use of and communicating over the communication link.
Process Control	A system of electronic equipment used to monitor conditions within a manufacturing process or utility operation. The system may also automatically regulate the process in such a way to keep a controlled variable constant or to optimize the process.
Process	The collective functions performed by equipment in which variables are to be controlled.
Process Descriptor	A descriptive message shown at the bottom of the Group-Display when a particular tag name is selected.
Process Library	A file consisting of words created by the user, which he then draws on by assigning numbers to specific point tags during point configuration.
Process Variable (PV)	An analog or digital signal representing the level or status of a process measurement, (e.g., temperature, pressure, etc.).
Program Load	A feature which allows the operator to implement a small bootstrap loader program in memory.
Proportional Band	The reciprocal of proportional controller gain, corresponding to the input change required to produce a full range change in output.
PV Tracking	A technique whereby the local set-point of a controller follows the process variable when in the manual mode.

R

Range	The region between the limits within which a quantity is measured, received, or transmitted. Expressed by stating the lower and upper range-values.
Range, Elevated Zero	A range where the zero value of the measured variable, measured signal, etc. is greater than the lower range-value.
Range-Limit, Lower	The lowest quantity that a device can be adjusted to measure.
Range-Limit, Upper	The highest quantity that a device can be adjusted to measure.
Range, Suppressed Zero	A range where the zero value of the measured variable is less than the lower range-value. Zero does not appear on the scale.
Range-Value, Lower	The lowest quantity that a device is adjusted to measure.
Range-Value, Upper	The highest quantity that a device is adjusted to measure.
Real Time Clock	The circuitry which maintains a reference in program execution and event initiation.
Real Time Trend	A display of process variable magnitude displayed against a time base.
Redundancy	The use of duplicate cables, modules or devices to minimize the chance that a failure might disable an entire system.
Relative Address	A label used to identify the location of data in a program by reference to its position with respect to some other location in that program.
Reset	A non-processing condition of certain intelligent devices (e.g., Controllers) caused when the microprocessor determines a diagnostic failure has occurred. Depending on the system, valve outputs may be frozen at their last position. 2. Integral control method.
Resistance Temperature Detector-(RTD)	This sensing device consists of a coil of fine wire. Its electrical resistance changes with temperature in a predictable manner. By measuring the resistance of the coil, its temperature can be determined.

S

Scan	To examine data from multiple sensors, usually through a multiplexer.
Screen Copy	A hard copy reproduction of the Operator Station video display.
Scrolling	A method of writing the most recent row of characters onto the bottom or top of a video display after moving the older rows up or down respectively, by one line. The oldest line moves off the screen. For example, the top row (if any) moves off the screen as each new row of characters is added at the bottom.
Self Diagnostic	The self-checking operations performed by various system devices usually when powered on, or reset.
Sensor	An electrical or mechanical device which produces digital code, voltage or current when used to measure some property of the process (e.g., temperature, pressure, etc.).
Setpoint	A paramater which represents the desired value of the controlled variable.
Shed	The process of eliminating one device's influence (i.e., load or control) over another device, usually to achieve more limited but more predictable operation.
Single Loop Standby	A device which allows the operator to assume manual control of a specific loop, thereby providing a hard manual output that bypasses the Controller.
Slot	One of a number of user accessible processing blocks within the Controller. 2., The physical area, usually including a connector and edge guides where an electronic board is held.
Slot Selector	Push buttons on a controller or keys on an Operator Station's Keyboard that are used to select information from a computational slot in a Controller or position in a group for display.
Smoothing	A technique to decrease or eliminate rapid data fluctuations.

Status Codes	Information used to indicate the state of condition of system components.
Supervisory Control	Process control systems in which a digital computer is programmed to determine process parameters such as flow rates, pressures, temperatures, etc. It then either prints out information for use by an operator to manually adjust appropriate setpoints, or automatically sets those points itself.
Supervisory System	A computer based process control system

T

T-Connector	A coaxial connector shaped like the letter T. It allows devices to tap into a coaxial cable.
Tag	Information which is used as an identifier or label for other information. The term is often used synonymously with "point".
Target Value	Desired Operating value of a non-controlled process variable indicating point which is commonly associated with Analog Units.
Terminator	A resistor used at the end of a cable or bus to reduce signal reflections.
Three Mode Controller	A controller which provides proportional gain, plus integral, plus derivative action. Also known as PID controller.
Time Out Gate	An internal counter within the Controller that must be reset periodically by an on-line computer otherwise the Controller will shed to the backup control strategy.
Total Distributed Control	A concept using the principle of partitioning control task and function into system modules. These modules are tied together by a communication link so that total control is maintained throughout the distributed hardware.
Traffic	Term used to describe the flow of data over the communication link.
Trend Display	A display that shows the process variable versus time relationship for a point. A

	graph representing the value of a point over a period of time.
Trend Selector	Device used with conventional pen recorders to select trend points from those inputs wired to the recorder terminal panel.
Two Mode Controller	A controller which provides proportional gain plus integral action. Also known as a P1 controller or proportional plus reset controller.

<u>U</u>

Update	To modify a video display according to current information.
Uninterrupted Automatic Control	A subsystem that, upon detecting a malfunction, automatically switches in a Reserve Controller and continues operation in the original mode.

<u>V</u>

Video Copier	An option that provides a permanent copy of the video monitor's display.
Video Display Monitor	A television-like device used to display letters, numbers, etc. and sometimes graphic symbols. Some monitors are combined with a keyboard and a display generator in a single housing and referred to as a terminal.

<u>W</u>

Watch Dog Timer	A monitor circuit which establishes a definite period of time within which the device must complete certain operations (e.g., at least one interrupt per second, etc.). As long as the operational sequence is completed within the prescribed time period, the timer is reset. If the timer is not reset within the prescribed period of time, the circuit will alarm and/or halt device operation.

ABBREVIATIONS

A

A	Accumulator
A/D, ADC	Analog to digital converter
ATE	Automatic test equipment

B

BAUD	Baudot, Rate of bit transfer on communication link
BCD	Binary Coded Decimal
Bit	Binary digit

C

C	Celsius of Centigrade
CM	Computer/manual or common mode
CMR	Common mode rejection
CMV	Common mode voltage
COS	Computer operator subsystem
CPU	Central processor unit
CRT	Cathode ray tube

D

D/A DAC	Digital to analog converter
DAS	Data acquisition system
DDC	Direct digital control
DMA	Direct memory access

E

ECP	Executive control program
EMI	Electromagnetic interference

F

F	Fahrenheit
F/F	Flip flop
FT	Free time

I

I	Current flow
IC	Integrated circuit
ID	Point identification
i.e.	That is
I/O	Input output
IS	Intrinsic safety

K

K	1024 or 1000
KSR	Keyboard send/receive

L

LED	Light emitting diode
LPM	Lines per minute

M

MA	Milliamp
MUX	Multiplexer
MV	Millivolt

N

NMR	Normal mode rejection

P

PCFA	Point card file assembly
PID	Proportional, integral, derivative
PMC	Process monitor and control
PROM	Programmable read only memory
PSI	Pounds per square inch
PV	Process variable

R

RAM	Random access memory
RO	Response only
ROM	Read only memory
RTD	Resistance temperature detector

S

SP	Set point
S/R	Send/Receive

T

TDC	Total Distributed Control

U

UAC	Uninterrupted automatic control

APPENDIX B

Excerpts from Control System Manufacturers Literature.

The following excerpts from the control system manufacturers literature are presented in the order used in the comparison chart and discussion and are not in any particular rank. An attempt has been made to include about four pages from each manufacturer and to screen it so that the most encompassing material is presented, but uniform treatment is not possible since some treatment is general sales platitudes while other treatment is technical, specific and pertinent. It is unfortunate that this literature cannot be presented in color, as the display pictures of most manufacturers are very impressive. Also it has been necessary in some cases to do considerable chopping and rearranging to get both general and specific material included.

A. Leeds & Northrup–MAX 1

MAX 1 Controller

The "controller" in the MAX 1 system is a microprocessor-based multi-loop control module, comprising a selection of standard, interchangeable printed-circuit cards mounted in the controller-file housing.

Choice of a Loop Controller (primarily analog functions), a Logic Controller (digital functions only) or a Batch-type Controller (analog and digital functions) offers a cost-effective approach to specific requirements.

Current output is 0-16 or 4-20 mA. The triac-switching output—energizing a motor-to-pneumatic converter, or a valve-drive mechanism—provides inherent fail-safe operation, since the end-device remains in its last position in case of control or power failure.

The controller accepts up to 30 analog inputs, and provides up to 8 analog outputs; up to 256 digital inputs and outputs, in any combination, can also be processed.

Sixteen "time-slots" are available in each controller: 8 "primary" slots, each with an analog output, plus 8 "auxiliary" slots (for computation, cascading, etc.) which can provide external digital outputs. The microprocessors sequentially scan these slots (twice each second), performing whatever operation on the data is required by the specified slot configuration . . . thus, in effect, synthesizing a multi-loop controller and accessory equipment. Configuring the slots, from a choice of 40 discrete algorithms—a pushbutton selection quickly mastered by plant operating personnel—is accomplished through the operator Mini-Station. (Keyboard can be locked.)

Algorithms

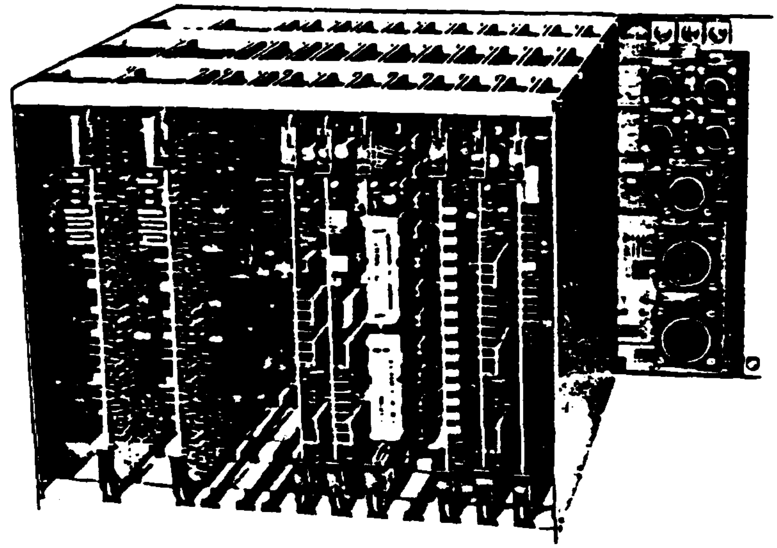
An algorithm is a step-by-step procedure for solving a problem or accomplishing a desired result. The function of each time-slot in a MAX 1 controller file is uniquely defined by the algorithm selected to meet the requirements of the process. The slot is configured to perform that function by the algorithm, by parameters specific to the process, and by input-source and output-destination information.

Thus a slot may be configured as a PID algorithm (Proportional, Integral, Derivative) to develop a proportioning control output in response to a process-variable input and a reference input (as determined by the set point), and proportional, integral (reset) and derivative (rate) values.

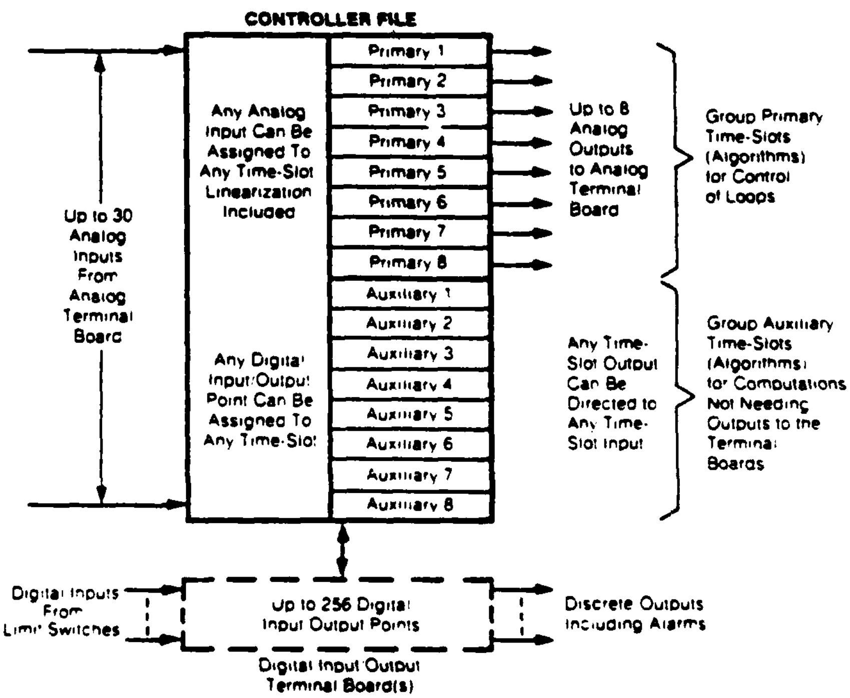
During the time the microprocessor handles a slot—1/32 second—the controller file exercises the specific functions defined by its algorithm, selecting its input(s) from the indicated terminal(s) or other sources as configured, and directing its output to a specified terminal. Speed of scanning—twice per second—is more than ample for industrial process applications, producing, in effect, continuous functioning of each slot.

MAX 1 offers a complete array of conventional control-function algorithms, such as PID (five variations), multiplier, divider, etc.; advanced control algorithms, including two-mode adaptive tuning and non-linear function generators; logic control functions, including a chainable 8-step, 8-output sequencer, Boolean logic, timers and counter, and a ramp generator for set-point programming.

An easy-to-use, effective alarm-and-mode interlock system can provide many interacting functions between loops without the need for additional slots. A single controller file can thus accommodate many more functions, reducing the need (and cost) for additional hardware.

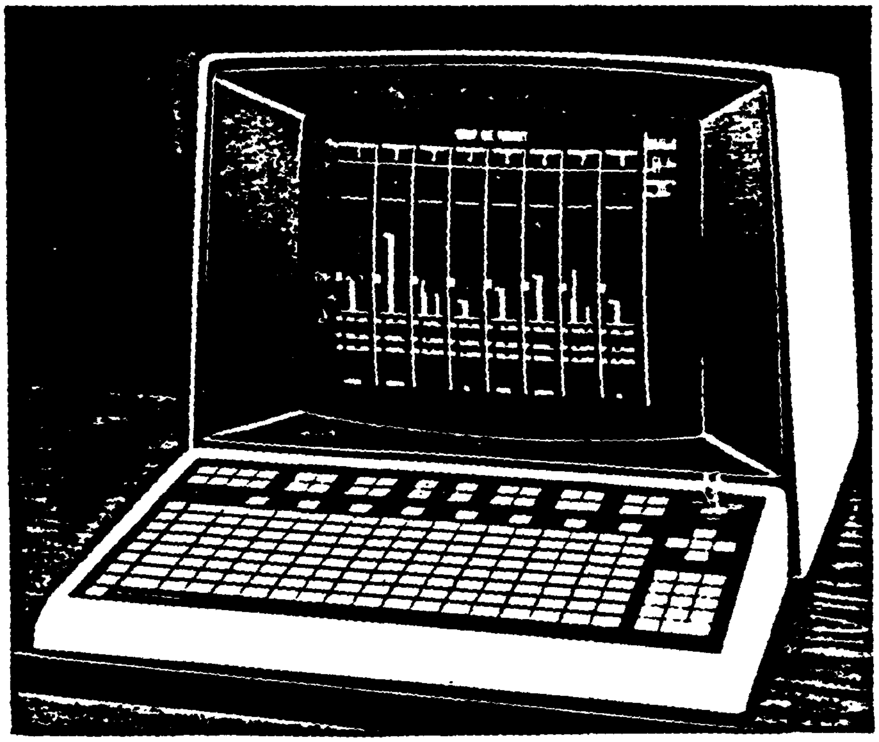


MAX 1 Controller File (with Optional Redundant Power-Supply Card)



INPUT/OUTPUT OPERATION: MAX 1 CONTROLLER FILE

A. Leeds & Northrup–MAX 1



Operator Mini-Station: The Window to Your Process

The MAX 1 Operator Mini-Station, with its multi-color video display of data and its Data Input Keyboard, provides an open window to the process and fingertip command of its operation. Each Mini-Station can configure, monitor and display data from up to 8 controllers (or a total of 64 analog control loops), as well as all the auxiliary functions. Conversely, each controller can be cable-connected to two Mini-Stations, either of which can input data to, or display data from, the controller. (Another controller connection is available for a third Mini-Station or a Records Station, described on page 8.)

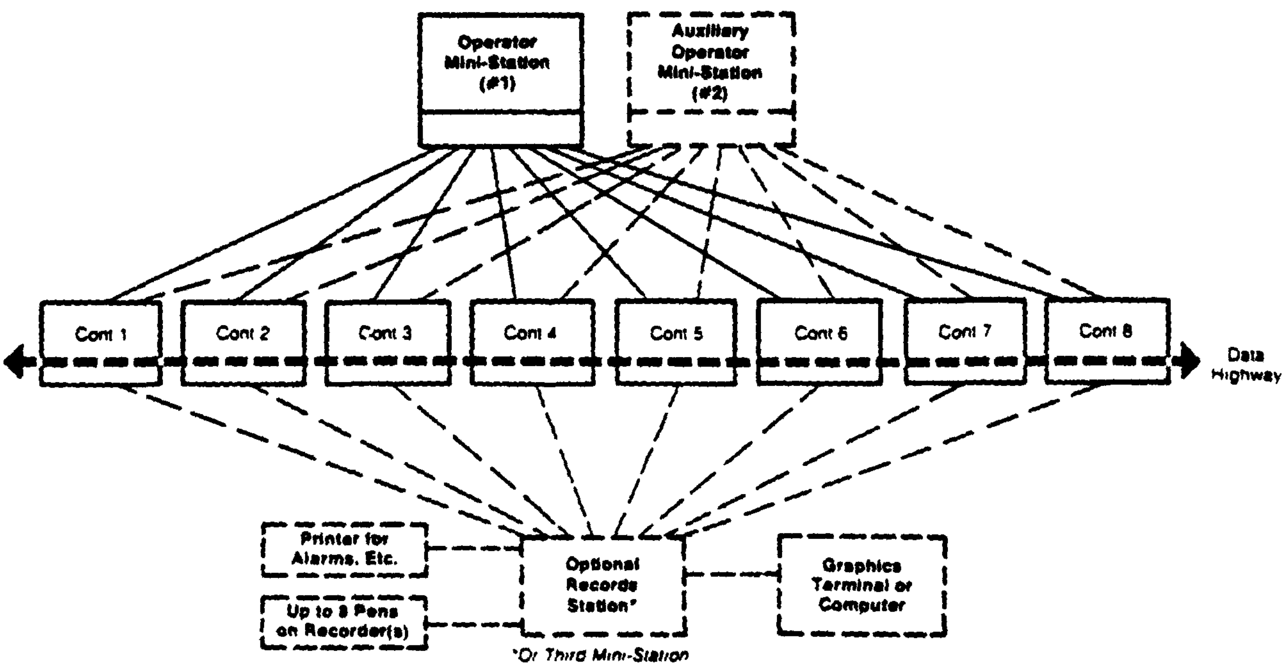
A ratio of two Mini-Stations to every 8 controllers, in any combination, can provide redundant Mini-Station backup—but note that controller *operation* is independent of the Mini-Station: control, alarming and other functions continue even if the Mini-Station is disconnected. Controller data-base is maintained by long-life batteries during power upsets. Capability for automatic redundant control-loop backup is a standard feature: a single primary slot, or up to eight, in one controller file can be backed up by a configured slot in another controller file. And with plug-in cable connections (no data highway required), MAX 1 Distributed Control can be cost-effective for as few as 8 control loops.

Operator Mini-Station: Video Display

The high scan-rate CRT offers a combination of seven colors, for either data or background, to contrast the differences in data displayed and improve the "man/machine" interface.

Through Keyboard selection (described below), the video screen can provide three types of displays:

- Group Display: current operating data for all eight primary or eight auxiliary slots.
- Detail Display: current operating data, historic or real-time trend curve (if applicable), and configuration data and parameters for a single slot.
- Process Input Display: current values and engineering data for all 30 analog inputs.



REDUNDANT MINI-STATION BACKUP

A. Leeds & Northrup-MAX 1

Group Display—A Group Display shows relevant operating data, in bar-graphs and numerical values, for 8 slots of a controller file—either Group Primary (control) or Group Auxiliary slots, as selected. Data includes:

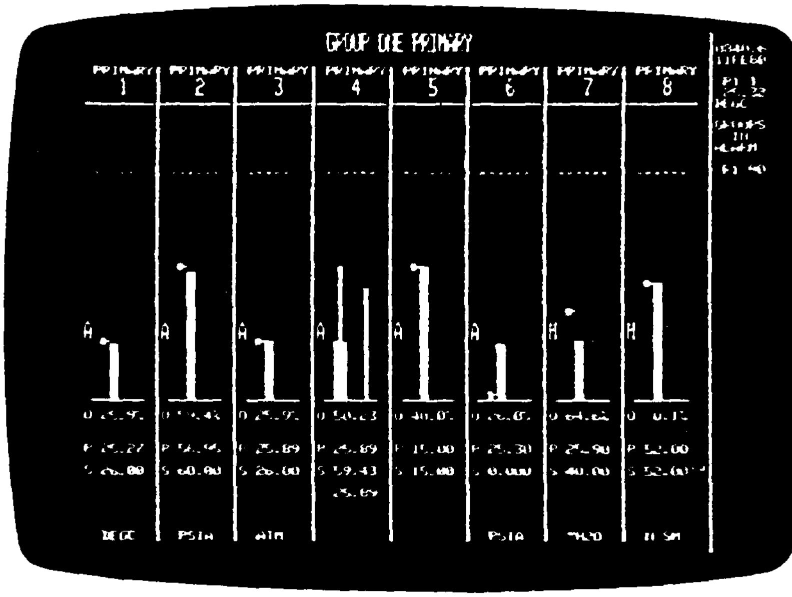
- Controller file identification ("GROUP ONE PRIMARY", "GROUP THREE AUXIL", etc.)
- Eight adjacent vertical displays, one for each slot, each with
  ... an identifying head (e.g., "PRIMARY 1")
  ... a base line and upper row of dots to define 0-100% of range (2¾" high), with one or more bar-graphs representing inputs (resolution, 1.25%) and a set-point index for controllers, in a format like the familiar vertical-scale indicator
  ... a letter defining control mode ("A" for automatic, "C" for cascade, "M" for manual)
- Three numerical values beneath the bar-graphs: output ("O") in percent of output span, and process variable ("P") and set point ("S") in the engineering units indicated (e.g., "GPM", "DEGC"). (For algorithms other than PID control, the numerical values of the output and inputs are displayed.)

In the extreme right-hand column of the Group Display—and repeated in all Detail and Process-Input Displays—are

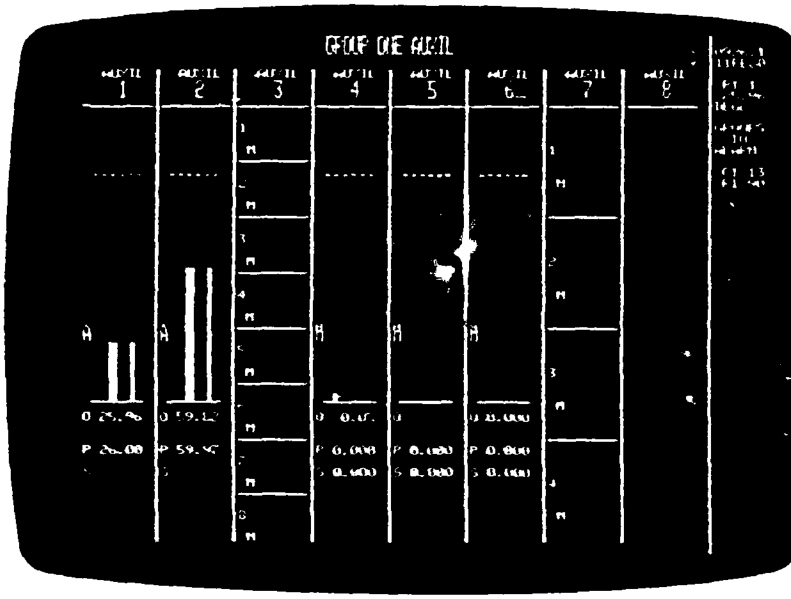
- Time, in hours, minute and tenths of minutes ("1359.9")
- Date, in international format of day, month, and year ("12JL80")
- One selected process-variable input, with identification (controller-file and process-variable input number), value, and engineering units ("P1 1", "3.002", "FT")
- A list of all points in alarm status (up to 34) in all Groups connected to the Mini-Station, and diagnostic alarms resulting from hardware or software errors in the Operator Mini-Station or a Controller.

In the Auxiliary Group Display, any slot can be configured for any algorithm, but an analog "output" can only be used internally within the controller; for example, the output of a cascade control slot in the Auxiliary Group can be input to a control slot in the Primary Group, or outputs from summers, multiplier/dividers, selectors, etc., can be similarly routed internally.

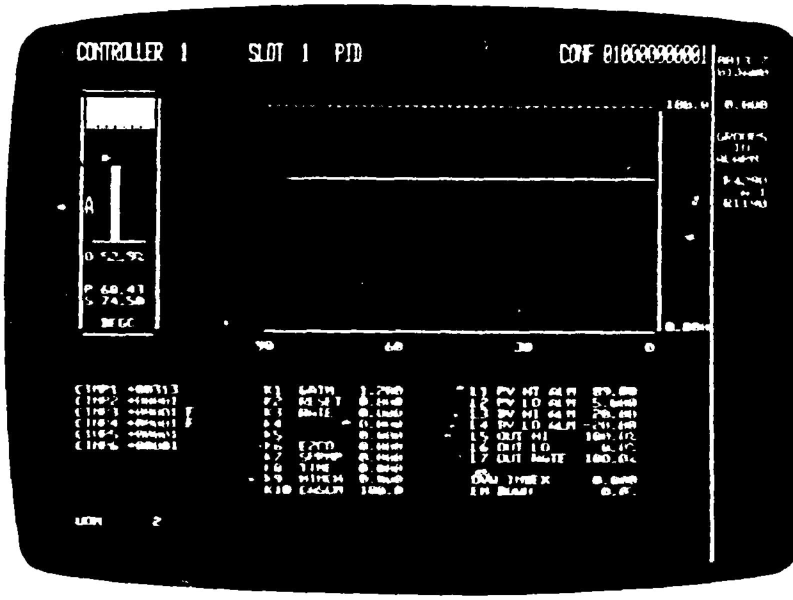
In addition to such analog displays, logic and alarm displays can be provided, and each slot can be configured to display 1, 2, 4 or 8 separate channels. Each channel within the slot has numerical identification ("1", "2", etc.), status identification ("ON" or "OFF", "OPEN" or "CLOSED", "HI" or "LO", etc.) and operation identi-



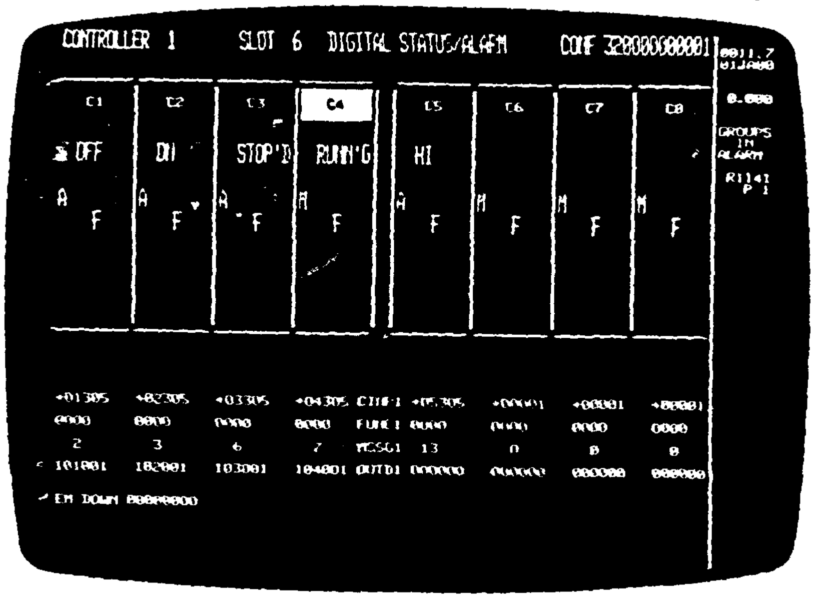
Group Primary Display



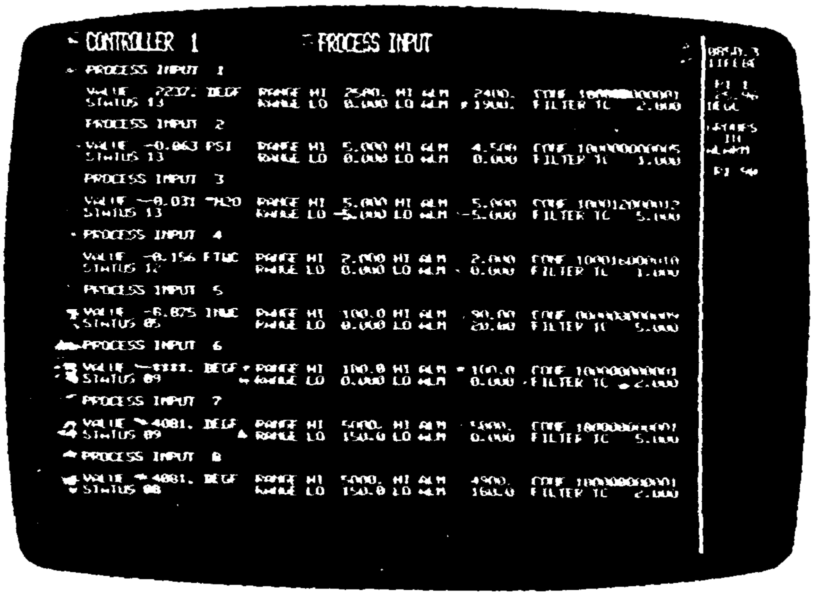
Group Auxiliary Display



Analog Detail Display



Digital Detail Display



Process Input Display

fication—automatic ("A") or manual ("M")

Availability of the Auxiliary Group slots provides a powerful tool to perform many signal conditioning or other auxiliary functions on any of the 30 analog inputs before introducing them into the Primary controllers, replacing the costly additional hardware normally required in traditional analog controller applications. And by processing digital input and outputs (with status display), the Auxiliary Group slots offer exceptional capability for interlocking, alarming, sequencing of events and batch control, in combination with PID analog control functions.

Detail Display—A Detail Display can be Keyboard-selected for any of the 16 slots (Primary and Auxiliary) of a controller file, to provide more specific data than a Group Display (and is required when configuring the slot). Each slot display is identified (across the top of the screen) by a controller-file number ("CONTROLLER 1"), slot number ("1" to "8" for Primary, "9" to "16" for Auxiliary), algorithm ("PID") and a 12-digit configuration "word" ("CONF 010020100001")

In a typical analog display for a control slot, the same data is shown as in the Group Display, but the bar-graph (in the upper left quadrant of the screen) is half-size (with 2.5% resolution). In the upper right is a horizontal display of the process-variable trend over the last 90 seconds, 45 minutes, 90 minutes or 24 hours (based on 90 samples). Newest point on the curve is added on the right, the entire curve shifting from right to left. Resolution of this trend is 1.25%, with the scale expandable to any convenient value. At the bottom are three groups of alphanumeric displays, identifying the inputs and their sources ("CINP1 00309"), parameters and their values ("K1 GAIN 1.000") and alarm settings ("L1 PV HI ALM 5.000").

Digital display (for logic alarms, etc.) presents the channel identification ("C1", "C2", etc.) status ("OFF", "DOWN") and operation identification ("A", "M") stacked vertically in a block for each channel. Each slot can accommodate 1, 2, 4 or 8 channels, depending upon the numeric configuration data which must be entered into the controller file (and displayed). Minimum requirement is one input source code ("CINP 1"), one function code ("FUNC 1"), one message code ("MSSG 1"), and, if a digital output is required, one output destination code ("OUTD 1"), which would permit 8 channels per slot.

Input Display—The process Input Display presents current values and configuration data for each of the 30 inputs connected to a controller file. The Display consists of four "pages" (selected through the Keyboard), with 8 inputs on each of the first three pages and 6 inputs on the last. Each input is described by three lines of tabular data; the first defines the input number (from 1 to 30); the next two display the current numerical value and status, the engineering units, the high and low range limits, the high and low alarm limits, the configuration code and the filter time constant (for input damping, if required). The display values are updated every two seconds.

The configuration word permits specifying linearization—such as square-root, thermocouple, or RTD—for any input, independent of the 16 time slots.

Similar to the algorithms themselves, input alarms can be interlocked with the appropriate operating algorithms without using additional slots. With no added hardware (or cost), this provides the capability—for example—to signal a transmitter failure to the appropriate control action, switching it out of cascade or into manual mode, or switching to another transmitter, or initiating a shut-down sequence to some safe condition for the process.

DCI-4000®

B. Fischer & Porter

A practical approach to distributed control

Distributed control is here to stay To those who operate continuous and batch processes. it offers a promise and a risk the promise of better control. more powerful and flexible than conventional panelboard instrumentation; and the risk of disrupting an effective and well-known process instrumentation skill with the unfamiliar technology of digital computers.

The *DCI-4000* Distributed Control Instrumentation Sys tem is a true distributed control system that delivers the promise but eliminates the risk. It is a hierarchical family of standard microcomputer-based products which can be assembled in a variety of ways to provide precisely the desired degree of distributed control at every process level, without incurring the necessity for custom design or programming work.

With *DCI-4000* instrumentation, you can make a capable entry into distributed control on a small scale, with as few as eight loops. You can do it at less cost than for a conventional panelboard of comparable capacity . . . and without disrupting conventional control of other process units in the same plant.

You can also expand an entry-level *DCI-4000* system to additional process units without sacrificing either its capability or cost-effectiveness. And—when *you* are ready for it—you can further expand your *DCI-4000* instrumentation to take over total control of your entire plant, including implementation of high-level control strategies and of a management information system by a supervisory computer.

A familiar and powerful operator interface

Nothing illustrates the unique Fischer & Porter approach to distributed control better than does the Local Operator's Panel (LOP), the basic operator-to-process interface in *DCI-4000* systems. A microprocessor-based instrument, the LOP provides all the display and process manipulation capabilities of a conventional panelboard . . and then some.

In a package that is about the size of an office word processor, the LOP combines a high-resolution CRT screen and a process-oriented functional keyboard. From this single convenient location, the operator can gain access to analog and digital displays of all process information—process variables and tren set points, controller outpu alarms, sequence and equ ment status displays—on many as 128 points. He ca also manipulate the contro parameters—setpoints, alarms, control outputs, au manual transfers, sequenc controls, controller modes for as many as 64 loops in tinuous and batch process

Although the LOP is bas on digital technology, it pr sents a familiar face to the operator since its use requ only the skills of process i strumentation and control. cause the format of its disp and keyboard emulate con ventional panelboard instrumentation, an operator begin to use the LOP immediately, with a minimum familiarization and without having to learn any compu skills.

lodular Hierarchy . . .

B. Fischer & Porter DC1-4000

/ITHOUT TYRANNY OR NARCHY

'ue to its name, a distributed ontrol system apportions ontrol functions at every level the process. It uses many icrocomputers to share the sk with a central minicompu-r, rather than concentrating ontrol functions in a single rge computer.

In the world of control sys-ms as elsewhere, distribu-on means a hierarchy, and e designers of such systems ust avoid placing undue mphasis at any level of the erarchy.

They must avoid tyranny, here the highest level is en-owed with so much power at the control system degen-ates into a sub-species of entralized computer control, id is economically feasible ily in large, plant-wide sys-ms. *DCI-4000* instrumenta-on avoids the problem by eparating the direct digital ontrol function from the central computer, and by endowing the basic level of the hierarchy with the intelligence and power it needs to do the job capably . . . for continuous and batch processes. That's the reason why *DCI-4000* instrumentation provides a cost-effective entry into distributed control for small process units.

They must also avoid imposing the tyranny of a new technology on those whose traditional competence is process instrumentation, not digital computers. *DCI-4000 instrumentation achieves this* purpose with such deliberate emphasis that process engineers and instrument operators find it actually easier to understand and use than conventional instruments.

And they must avoid anarchy, where the lower levels are so inflexible that they cannot share functions effectively with the higher levels without extensive custom design and programming *DCI-4000* instrumentation achieves this aim through a family of modular digital instruments which are plug-to-plug compatible at every level. They can be combined to serve a process of any size and to provide the desired degree of distributed control, without custom system design work or user programming.

Figure 1/At the Basic Level of the *DCI-4000* hierarchy, a Local Operator's Panel (LOP) combines with 1 to 4 Distributed Control Units (DCU) to form a complete control system for 8 to 64 loops in continuous and batch processes. In addition to performing all the functions of a conventional panelboard, the basic level also provides the capability for high-speed communications with higher-level devices, through the data highway which links all levels into an effective hierarchy for process control.

At the operations level, a Central Operator's Panel (COP) displays as many as 512 variables and provides access to as many as 256 loops, from DCUs located o one or two data highways, each of which can be 1.2 mi (2 km) long. It performs the same functions as the LOP and, in addition, has the capability of generating sp cial graphic displays with l process data, data summar displays, analog trend calc lations for 128 process vari ables, with simultaneous di plays of four at a time; and event recording and loggin

At the supervisory level, central computer may be u in addition to or instead of or more COPs, depending the size of the distributed c trol system. The computer plements high-level contro strategies by passing instru tions to all system DCUs, a collects information for dat processing.

B. Fischer & Porter

Easy to Use

The primary operator/process interface in *DCI-4000* systems, the LOP provides direct communication with as many as four DCUs. An independent data link—optically isolated and with plug-in terminations—connects each DCU to the LOP which may be as far away as 600 feet. Together, the LOP and DCU perform all basic level functions:

- all process input monitoring
- all signal conditioning and conversion to engineering units
- all alarm detection and annunciation
- direct digital control of continuous and batch processes.

The LOP is related to a DCU in the same way that a panel mounted control station is related to the controller in split-architecture instruments. It *displays* all process information and its functional *keyboard* allows the operator to select the desired display and to manipulate all process control adjustments

Displays. Three types of displays are available: All are illustrated on the next two pages.

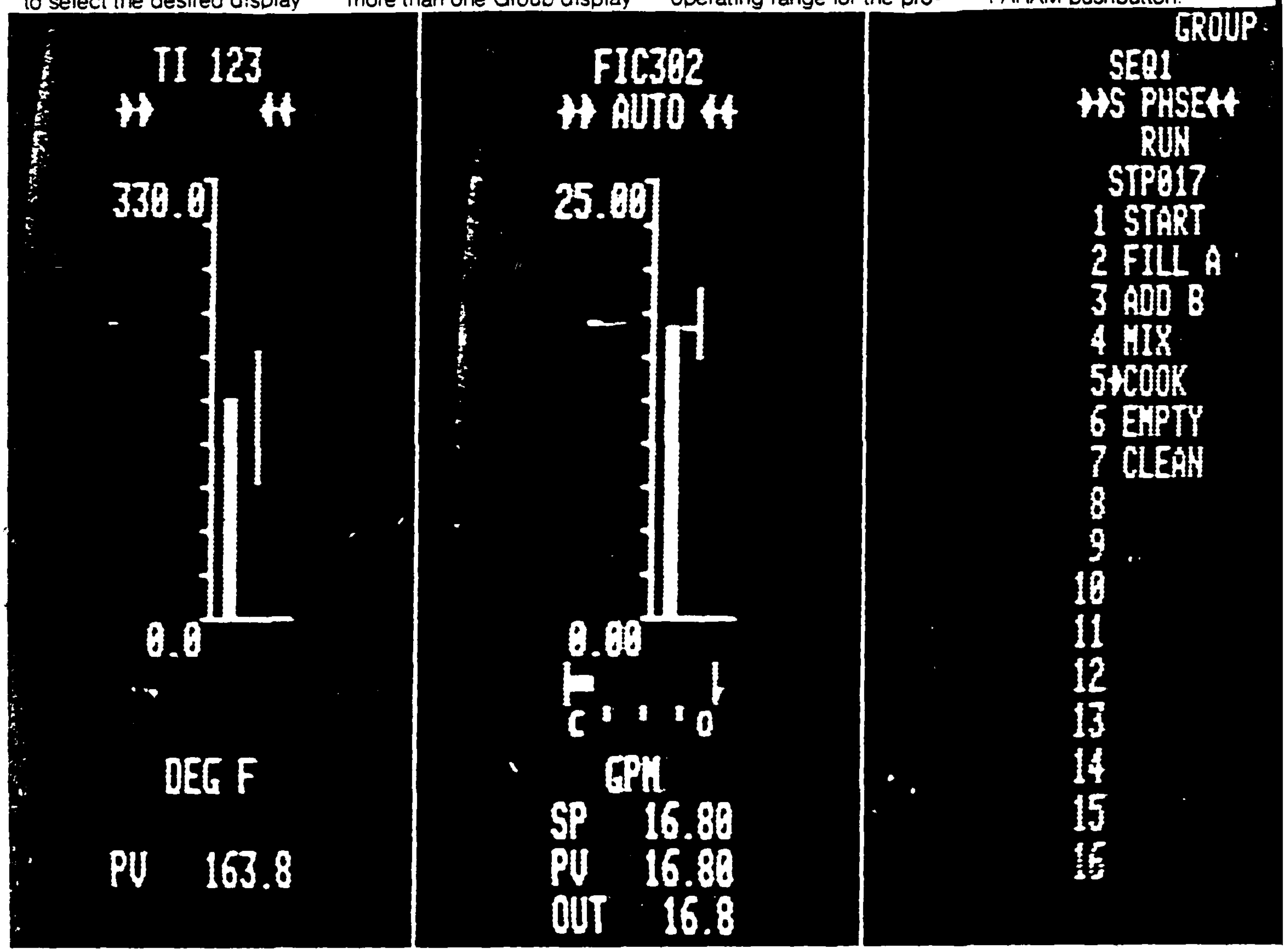
- The SUMMARY display shows all points identified by tag number and arranged in functional groups of eight. It also annunciates all abnormal conditions by flashing the tag name in reverse video and generating a code which identifies alarm, bad input or out-of-service conditions. The process engineer has total flexibility in arranging the 128 points in functional groups.

- Each of the sixteen GROUP displays provides detailed information on eight points—any combination of analog controllers, indicators, sequence listings and status displays of program curves, timers and counters or two-state devices. Each point may be assigned to more than one Group display for operating convenience, and each display may include points from any of the four DCUs that are connected to the LOP. The display format is fixed by the *Controlware*™ when the loop is configured (see Page 13) and appears automatically when the operator calls it on the keyboard.

Any point in the Group display may be selected for expansion by pushing the appropriate numeric and the SELECT pushbuttons. Examples of *selected* displays are shown (left) for an indicator, controller and a sequence.

Double arrows at the top indicate that the point has been selected; engineering units appear on the scale and the current digital values of the process variable and control points appear at the bottom. For indicators, a narrow vertical bar to the right of the wide bar represents the normal operating range for the process variable, *i.e.* the absolu[te] alarm limits. For controllers, [a] narrow vertical bar extending from the short horizontal set point line indicates the limits of the deviation alarm. For se[-]quence displays, the current phase is marked by an arrow. For all displays, pushing the SELECT button automatically activates the contro[l] pushbuttons for that point, allowing the operator to manipulate all control adjustments.

- The POINT display—there are 128 available—further expands the amount of information and the degree of operat[or] control. It allows the operator to place a process variable o[r] trend measurement, with a selectable time base of 1 to 255 minutes. The LOP can keep track of four trends simu[l]taneously, displaying one trend at a time. The Point display also allows adjustment o[f] tuning constants and alarm se[t] points through the keylocked PARAM pushbutton.



Powerful

All direct digital control is performed by the DCU, the basic controller in *DCI-4000* systems. It is available in three modular versions: the ACU (Analog Control Unit) for continuous control; the MCU (Multifunction Control Unit) for both sequence and continuous control; and the PSU (Process Scanning Unit) which will be introduced for applications that require only process data communications with the data highway.

The DCU family constitutes an unusually powerful array of precise controls which can perform all of the following tasks:

- full digital control of continuous processes
- logic, sequencing and timing control for batch processes
- full choice of control action for each loop . . . from on/off to PID stations
- absolute and deviation alarms
- full range of signal conditioning . . . from t/c linearization to square root extraction
- a powerful set of calculations . . . from arithmetic to compensation for dead time lag
- transfer of all data in engineering units
- data communications with all *DCI-4000* instruments through the data highway.

The sheer power of the DCU family far exceeds the level achieved by conventional panelboard instrumentation. This power is built into each DCU, requiring no additional hardware or software. More important, it is easily applied by the control or instrument engineer, with no need for custom programming. As a result, *DCI-4000* systems actually deliver more control power—at a lower cost—than more elaborate digital systems which are less flexibly designed.

Analog Control Unit (ACU)

Designs for the continuous control of process variables such as flow, temperature and pressure, the ACU comprises all necessary hardware and software to control sixteen fully compensated gas flow loops. A smaller version is also available for eight loops.

Hardware. Each full-size ACU contains input/output circuit boards for:

- 48 analog inputs
- 16 analog outputs
- 16 contact inputs
- 16 contact outputs

Twelve plugs—each terminating eight inputs and eight outputs—allow convenient and easily-documented plug-in cable connections to field wiring at Custom Terminal Boards (see Page 11, detail, center in rack).

Plug connectors are also provided for thermocouple cold junction reference and for direct connection to an LOP.

An optional plug-in Data Highway Controller Board provides all necessary control functions for data communications with other instruments.

***Controlware*™** Each ACU contains the following complement of pre-programmed software modules (whose use and application are described on Page 13):

- **48 analog input modules**
- **16 analog output modules**
- **16 contact input modules**
- **16 contact output modules**
- **16 calculation modules**
- **16 control modules**

Multifunction Control Unit (MCU)

The MCU is capable of performing all the continuous co[ntrol] functions of the ACU *plu[s]* logic, sequencing and timin[g] functions. All functions may [be] softwired together to implement batch control scheme[s]. The MCU has the capacity f[or] sixteen continuous control loops and eight independen[t] sequences.

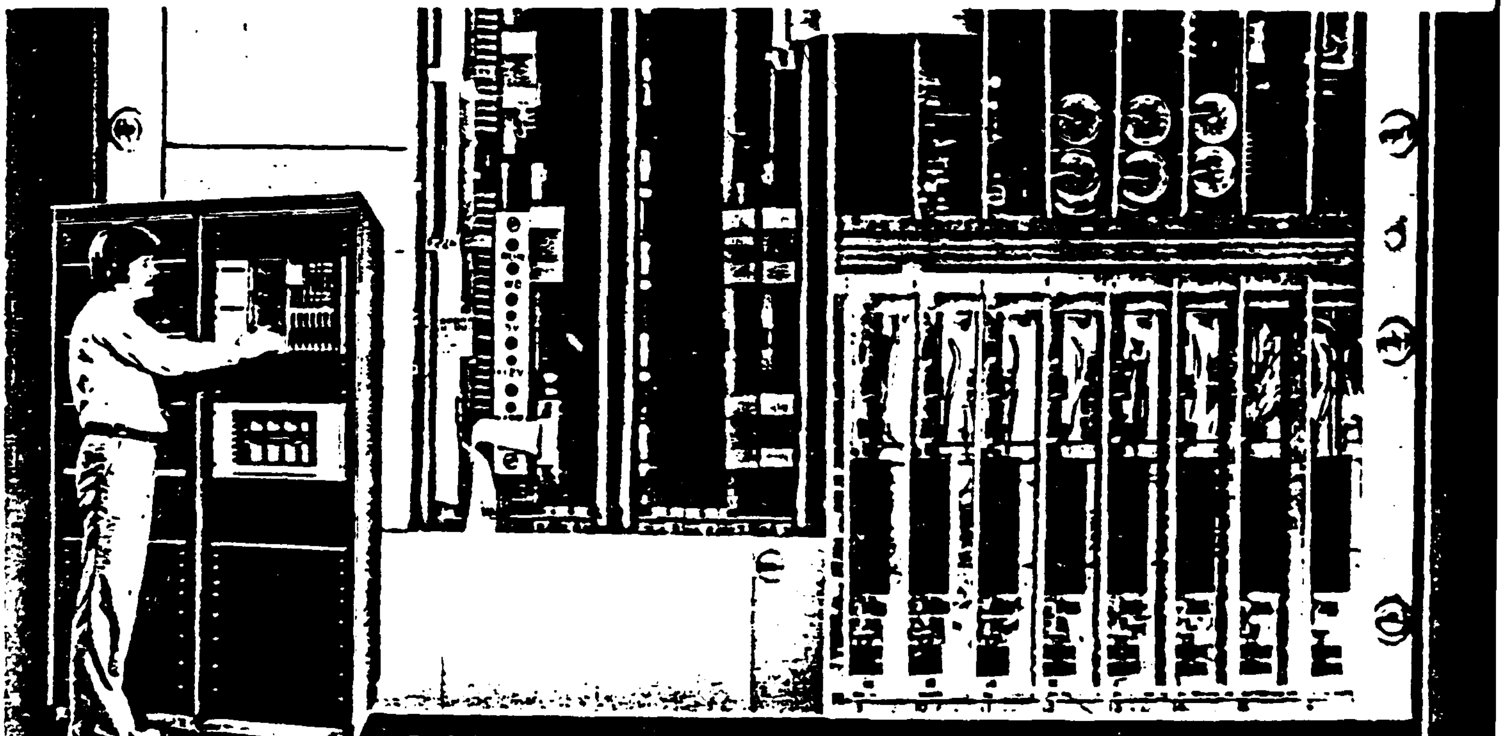
Hardware. Each MCU contains input/output circuit boards for

- 48 analog inputs
- 16 analog outputs
- 144 contact inputs
- 128 contact outputs

The remainder of the MCU is identical to that of the ACU.

Controlware. The MCU com[-]plement of *Controlware* includes all of the software modules of the ACU, and in addition

- **144 contact input modules**
- **128 contact output modules**
- **8 sequence modules**
- **255 step modules**
- **30 timer/counter modules**
- **32 memory/logic modules**
- **30 parameter modules**
- **8 security modules**



The DCUs are modular units which can be mounted in standard relay racks. All DCU components—microprocessor and optional Data Highway Controller as well as input/output hardware and software—are contained on plug-in circuit boards; and all interconnections with field wiring and other *DCI-4000* instruments are made through plug connectors.

C. Westinghouse-Hagen DCS 1700

The Westinghouse-Hagan Distributed Control System DCS-1700 is a central operator supervisory system. It employs a modular concept to minimize large and needless capital expenditures enabling you to buy only what you need.

The central operators interface to the process and the process control engineers interface to the control system is a Communications Control Console CCC-1600. The CCC-1600 provides the operator access to the process from a single location for control of up to 96 loops. The CCC-1600 was designed to facilitate coordination of up to sixteen model 1500 General Purpose Controllers (DB 106-410).

The 1500 GPC is an autonomous local controller. It controls up to six loops and contains 55 pre-programmed control algorithms. Each controller is an independent extension of the control system and is not dependent on the communication control console for its operation. To further enhance system reliability each 1500 GPC is seperately cabled to the CCC 1600 Communication Control Console for maximum system security. To further enhance system security four control loops in each 1500 GPC is backed up with a Track and Hold Circuit that under processor failure or power failure holds control output signals at last control points until further action can be taken.

The Communication Control Console uses a color CRT to display various levels of the process. Control decisions can be made quickly from displays showing an extensive process overview to displays showing all loop details. Control settings can be readily changed and loop tuning optimized from the operator console.

A keyboard, engineered especially for plant operators and process control engineers, compliments the color CRT display. The keys are grouped and color coded to maximize operator efficiency. Unique key assignments are made for quicker operator response. Some of these assignments are:

1. Alarm Acknowledge
2. Alarm Summary
3. Overview
4. Recall Last Display
5. Auto/Manual
6. Increase/Decrease

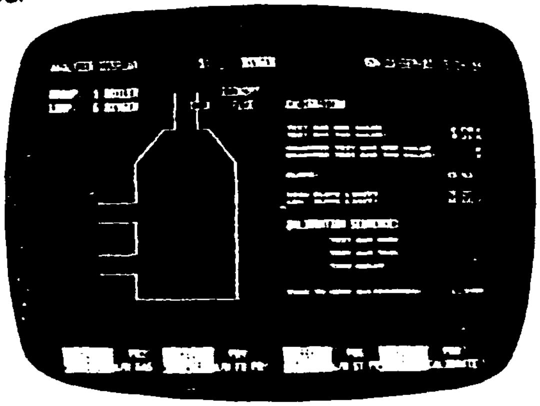
Features

- Distributed Control System
- Central Operator Supervision from 4 to 96 process control loops.
- A maximum of 16 Model 1500 GPC Controllers increases integrity control
- Modular concept to minimize large and needless capital expenditures.
- Operator oriented keyboard and block programming concept is easy to understand. Result is fast startup and fast control of an on-line system.
- Eliminates computer programming complexities and problems. ONLY SAMA analog knowledge is required.
- CRT Displays-Overview, Group, Loop Detail, Alarm Overview, Analyzer, Raw I/O, Group Configuration Block Detail, Diagnostics, System Names. Block Type Names, Operator Guide plus many others.
- Half Screen CRT Display.
- Full Screen Displays.
- Color CRT.
- Multiple Operator Display.
- Diagnostic Displays.
- System Configuration Displays
- Membrane Keyboard with clacker to provide both tactile and audible feedback to operator entries
- Computational functions performed in local controllers.
- Radial disbursement of local controls.
- Magnetic tape cartridge for configuration storage
- Local controller's configuration down loaded from central cassette.
- Local controller's configuration can be read back into central cassette.
- Autonomous local controllers.
- Group Controller integrity maintained.
- Dedicated manual back-up of all primary loops.
- Fast screen updates.
- Optional printer for logging and historical records.

Analyzer Display

Displays the process information associated with the analyzer option of the controller.

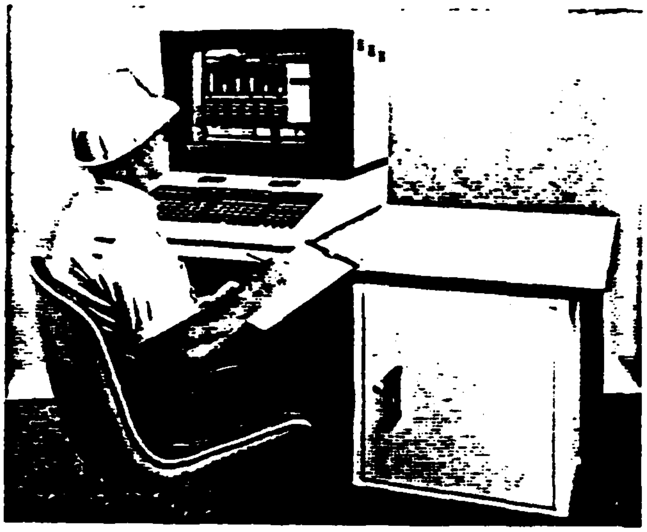
The automatic O_2 Analyzer calibration sequence and data is also displayed.



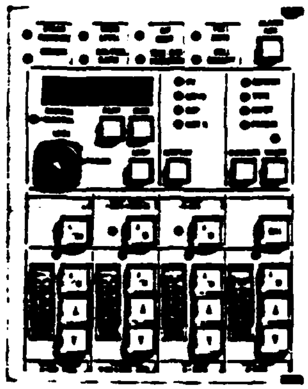
C. Westinghouse-Hagen DCS 1700

Basic System

Basic system for the Distributed Control System DCS-1700 includes Communication Controller CC-1600 on top of a desk which houses the electronics plus the General Purpose Controller 1500 GPC.



General Purpose Controller (Model 1500 GPC)



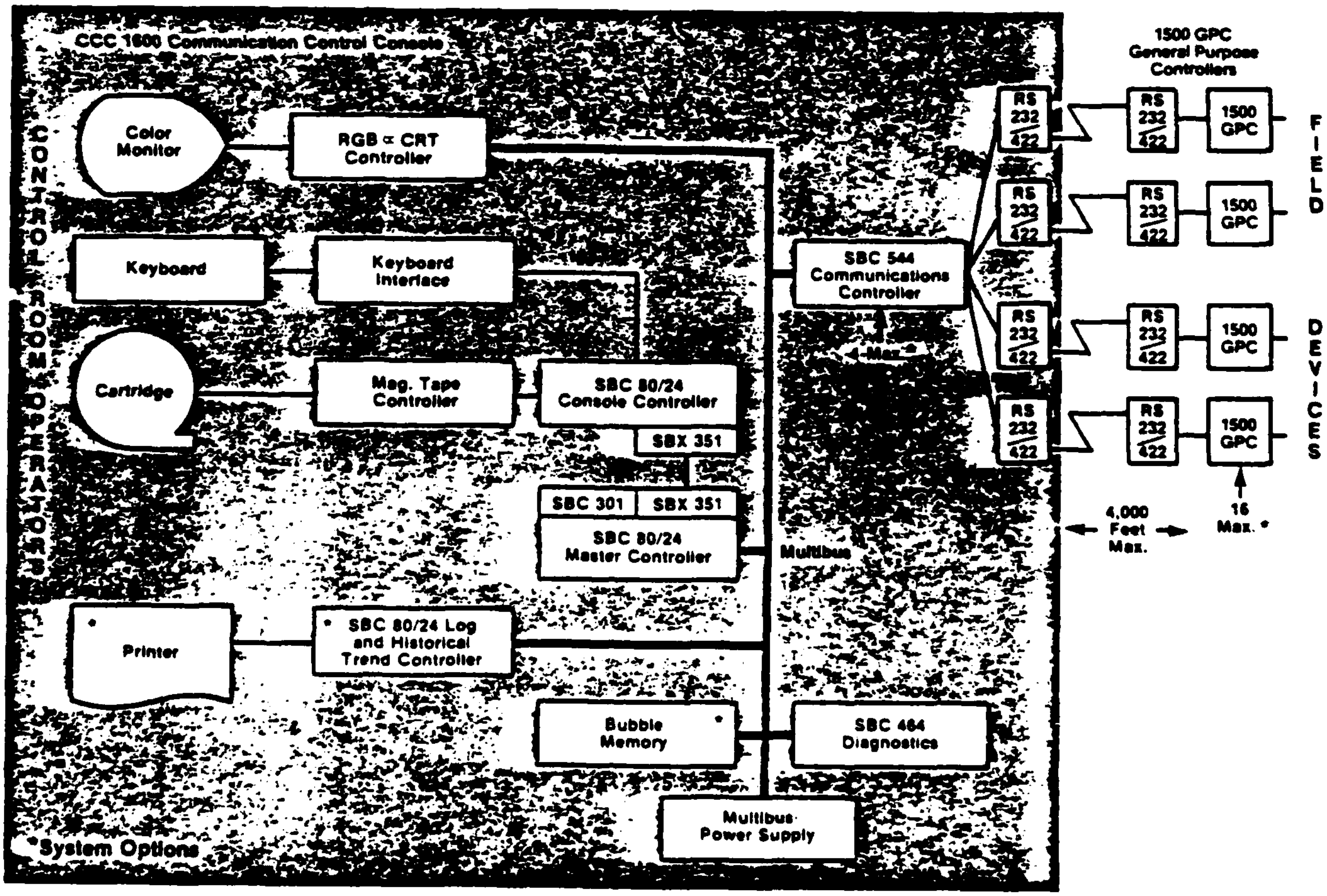
Microprocessor-based 1500 GPC is the local control for DCS-1700 System.

Each 1500 GPC features 6 Auto/Manual stations for control of 6 loops. These control configurations are entered by using blockware, a block oriented control language based on SAMA symbols. Each controller contains 55 preprogrammed control algorithms.

DCS-1700 System includes up to 16 Model 1500 GPC's.

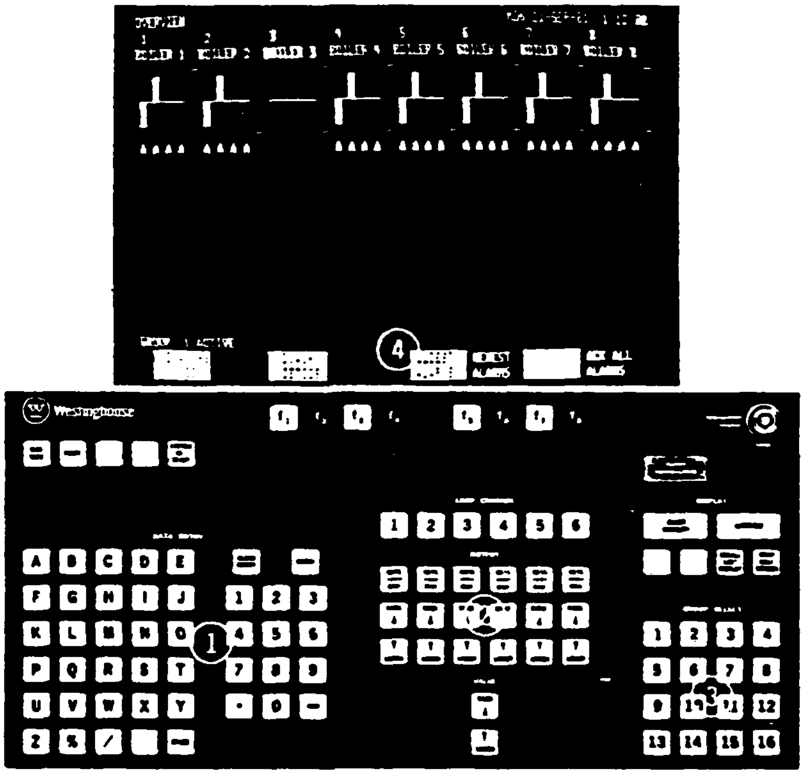
First out Annunciator Panel for alarm summary.

DCS 1700 DISTRIBUTED CONTROL SYSTEM



C. Westinghouse-Hagen DCS 1700

Easy to under system simplifies operation



① Configuration and Data Entry Panel

These keys are used for programming and overall system configuration.

② Loop/Auto/Manual Controls Panel

These keys define the 6 loops resident on each 1500 GPC and permit quick operator intervention with these conventional control functions.

③ Control Group Display Select Panel

These keys are used to call up each of the sixteen 1500 GPC's. The upper keys are for Alarm Acknowledge, Overview, Alarm Summary, Recall Last Display and Swap Half Screen. These are the Operators most frequently used interface.

④ Soft Keys Functions CRT Displayed

Soft key functions are only displayed on the CRT. Soft keys like the other keyboard keys gain operator or control engineer access to the control system. But access is only permitted when appropriate parameters are displayed on the CRT screen. Thirteen different CRT displays permit access to 100 soft keys in limited groups of eight keys. This approach to keyboard design increases operator efficiency so that under operating emergencies no time is lost responding to system needs.

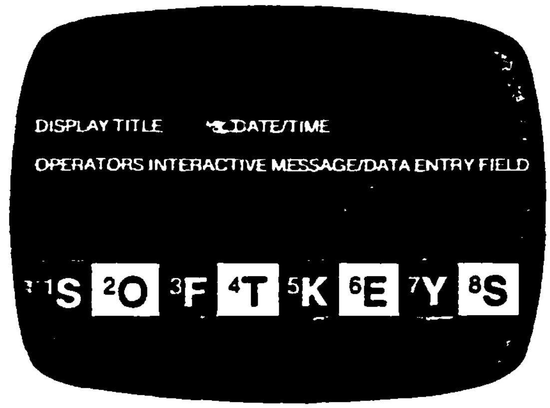
Soft Key	Alarm Summary or Overview	Group Select	Loop Control	Other Tuning or Loop Detail	Trend Display	Raw I/O Display Analyzer Display	Configure Summary	Block Display	Systems Names	Print	Mag. Tape	System Restart	Diagnostics
f1	Operators Guide	Block Display	Loop Detail	Block Display	Proc Var (PV)	PB1	Block Display	Block Display	Change Names	Copy Screen	Recall Configure	Set Date Time	Keyboard Test
f2		Raw I/O Display	Trend Display	Exit To Group	Aux Var 1 (AV1)	PB2	Block Configure	Duplicate Display	Name Alarms	History	Save Configure	Systems Reset	CRT Test
f3	Diagnostics	Configure Summary	Display Proc Var	Configure Summary	Aux Var 2 (AV2)	PB3	Change Blk Type	Configure Summary	Name Groups	Start Of Periods	Recall Names	Systems Name Load	Mag Tape Test
f4		Analyzer Display	Other Tuning	P Gain	Output (Out)	PB4	Blk Type Names	Previous Block	Name Loops	Event Log Off On	Save Names	Load All Groups	1500 Test
f5	Oldest Alarms	Exit To Group	Change Setpoint	I Reset	2nd Variable	PB5	Load From Group	Next Block	Name Eng Units	Define Variable	Rewind Unload	Complete Reload	Memory Test
f6	Newest Alarms		Local Remote	D Rate	1st Variable Off	PB6	Load To Group	Change Input	Name Aux Var	Print Configure	Initialize	Send Recv Message	I/O Status
f7		Service Group	Auto Manual	Set High Alarm	2nd Variable Off	PB7	Change Group No	Change Param	Name Buttons	Print Names	Label Tape	Save All Groups	Memory Display
f8	Ack All Alarms	Run Group	Change Output	Set Low Alarm	Freeze New Base	PB8	Systems Names	Next In Par	Name Next	Print Summary	Tape Label	Change Guide	Exit Test

C. Westinghouse-Hagen DCS 1700

Generic CRT Format Displays

Operator's Displays
- Overview
- Group
- Loop Detail
- Alarm Overview
- Tuning Trend
- Analyzer
- Operator Guide

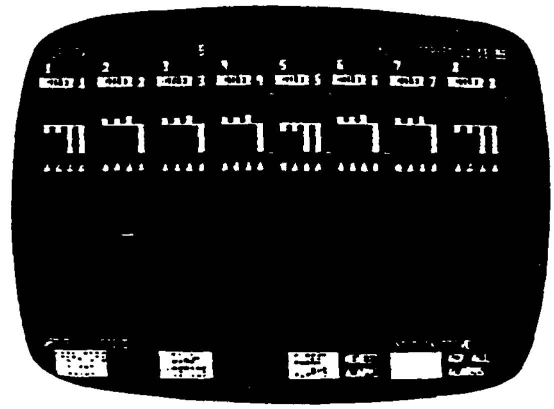
Engineer's Displays
- Group Configuration
- Block Detail
- Diagnostics
- System Names
- Block Type Names
- Raw I/O



Overview Display

Displays on overview of the control system. Included in the display summary are: Process Variable deviation from Setpoint, MANUAL/AUTO STATUS of the primary control loops, the operational status of the local controllers, and alarm status.

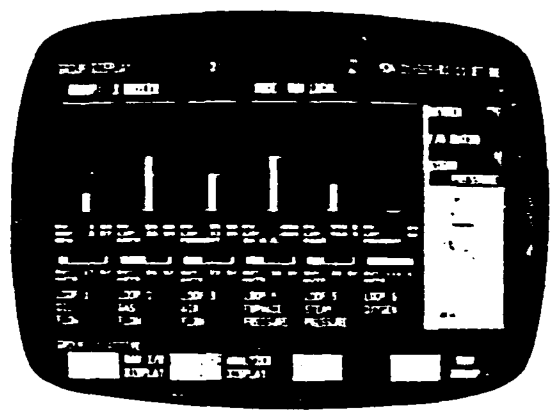
The OVERVIEW DISPLAY provides the operator with the means of visually scanning the entire process and identifying those loops which are off control point.



Group Display

Displays the setpoints, process variable and output of a group of loops. Also shows MANUAL/AUTO status of each loop as well as the Alarm Status of the group. (Data is displayed in both bargraph form and digitally in engineering units.)

Operator access for MANUAL/AUTO mode selection and manual operation of final control elements is permitted via the keyboard of any loop within the group on display.



Loop Detail Display

Displays the setpoint, process variable and output of a selected loop within a group. All of the significant loop constants such as alarm settings and controller settings are also displayed.

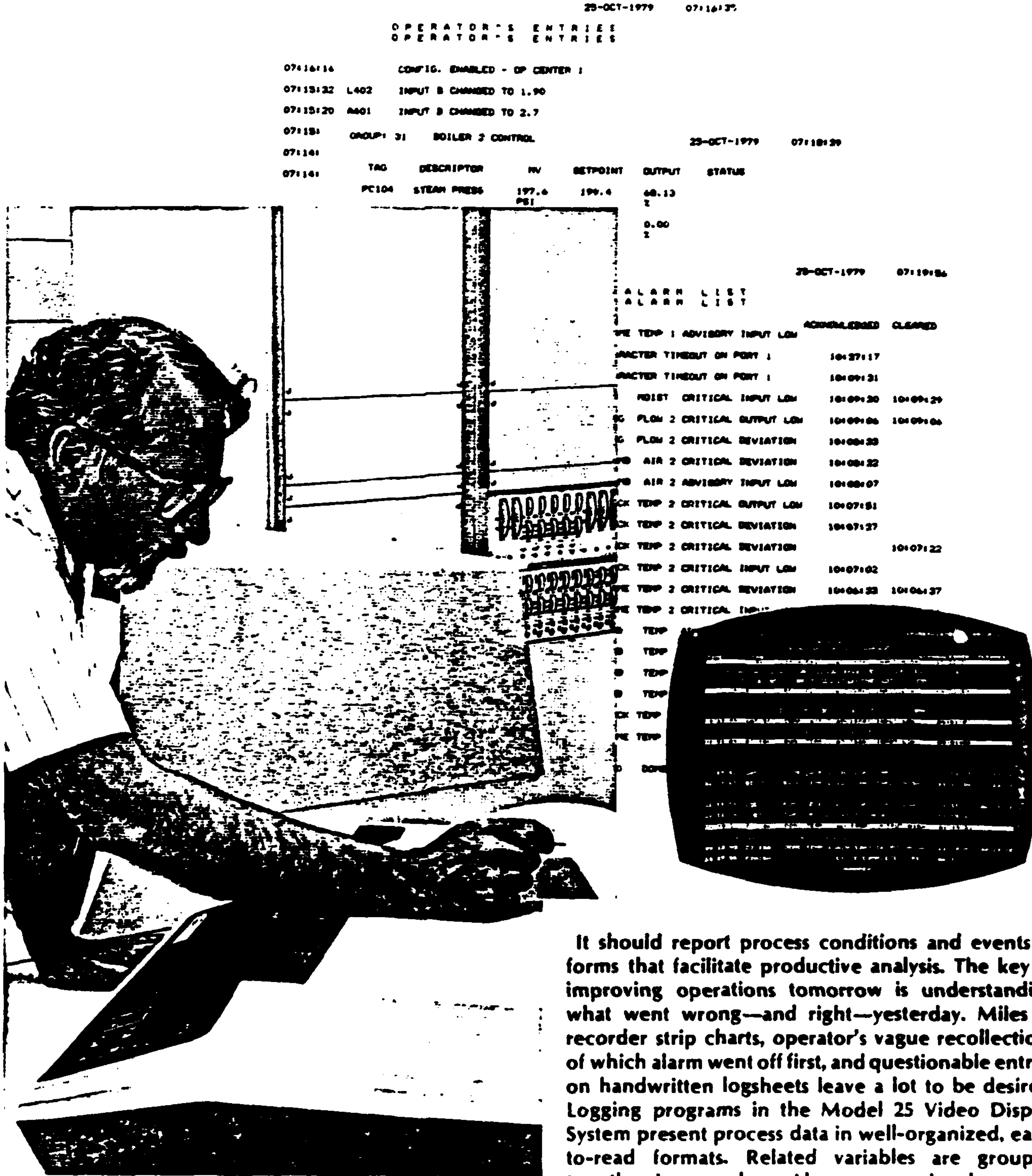
Operator access to loop constants via softkey and keylock is permissive.

Tuning Trend Display

Displays the values of two process variables over a period of time. Process trend is selectable from 2 minutes to 60 hours in eight steps.

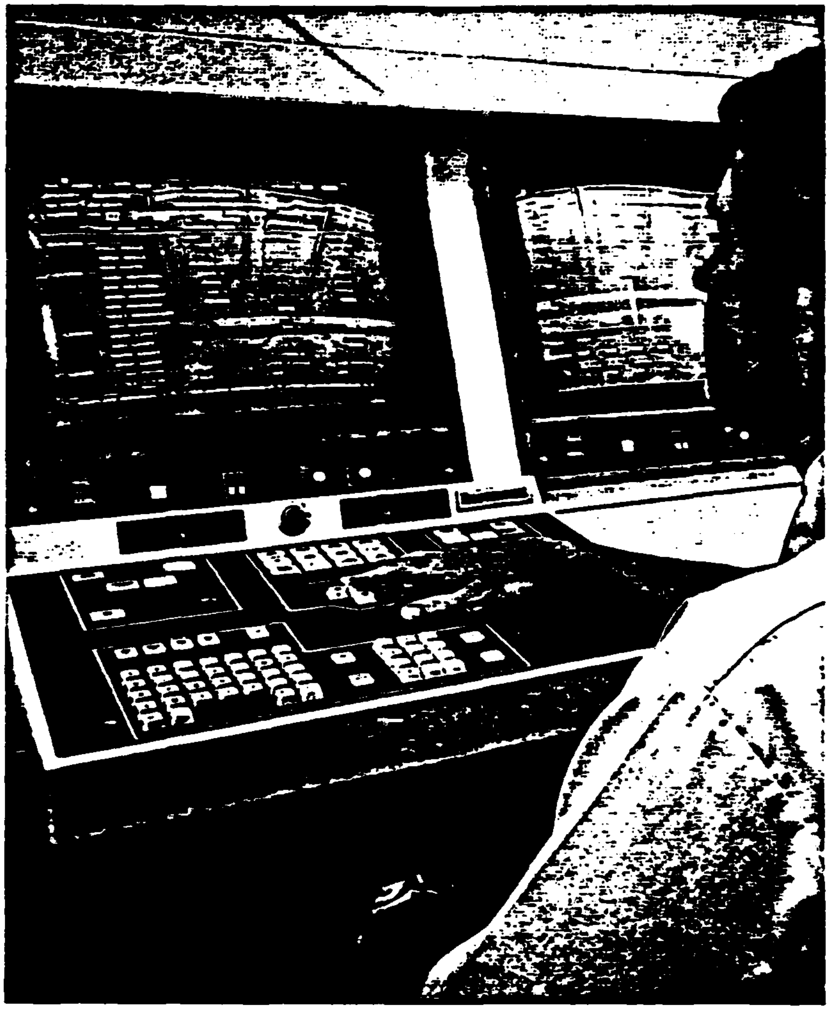
This display provides the operator with the means to tune the local controller for maximum process efficiency.

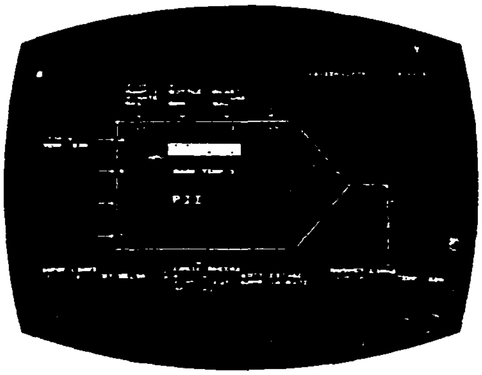
D. Rosemont–Diogenes

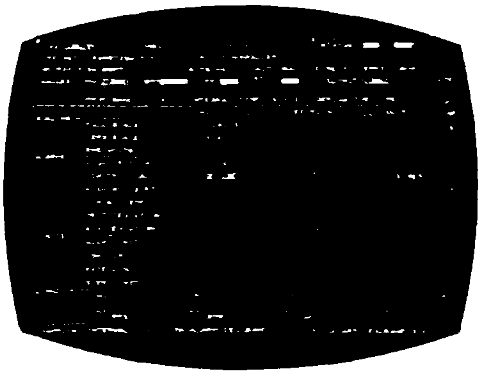


It should report process conditions and events in forms that facilitate productive analysis. The key to improving operations tomorrow is understanding what went wrong—and right—yesterday. Miles of recorder strip charts, operator's vague recollections of which alarm went off first, and questionable entries on handwritten logsheets leave a lot to be desired. Logging programs in the Model 25 Video Display System present process data in well-organized, easy-to-read formats. Related variables are grouped together in one place. Alarm summaries document problems completely and precisely—no missing information and no uncertainties about the sequence of events. Data is as accurate and trustworthy as the sensors that supply it.

D. Rosemont – Diogenes







It should adapt easily to changing requirements. This means not only changes in process design, but changes in operating philosophies as well. It should easily permit expansion or addition of new units, shifts to different or lower grade raw materials, or changes dictated by enhanced knowledge of your own process. And it should handle changes growing out of the inevitable errors in judgement or lack of information during the design phase.

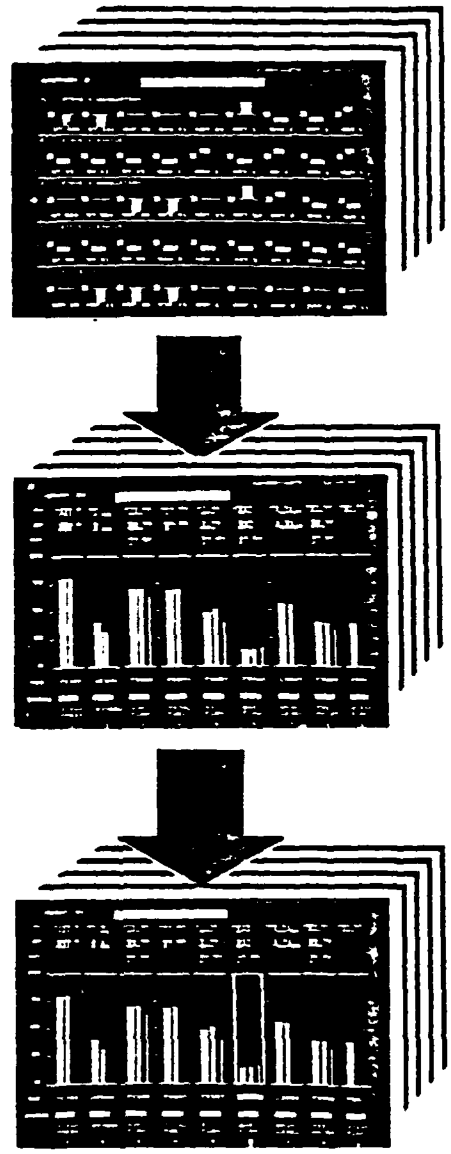
The system should adapt to these changes without the need to cut holes in panels, wait for needed hardware, change back-of-panel wiring, or unnecessarily interrupt process operation. It should allow you to try potentially beneficial new control strategies *without undue effort or risk.*

In a DIOGENES Multi-Loop Digital Controller, specific system configuration is stored as instructions in memory instead of as hardware mounted in panels and connected together with wires. Configuration changes take minutes instead of hours or days. Yet no software programming is necessary. Risk is minimized since the total impact of any configuration change is displayed on the CRT screen as soon as it is made. And the change can be completely documented in hard copy at the touch of a button. The DIOGENES System is a truly powerful tool for the control engineer.

D. Rosemont – Diogenes

BETTER ORGANIZATION OF INFORMATION –

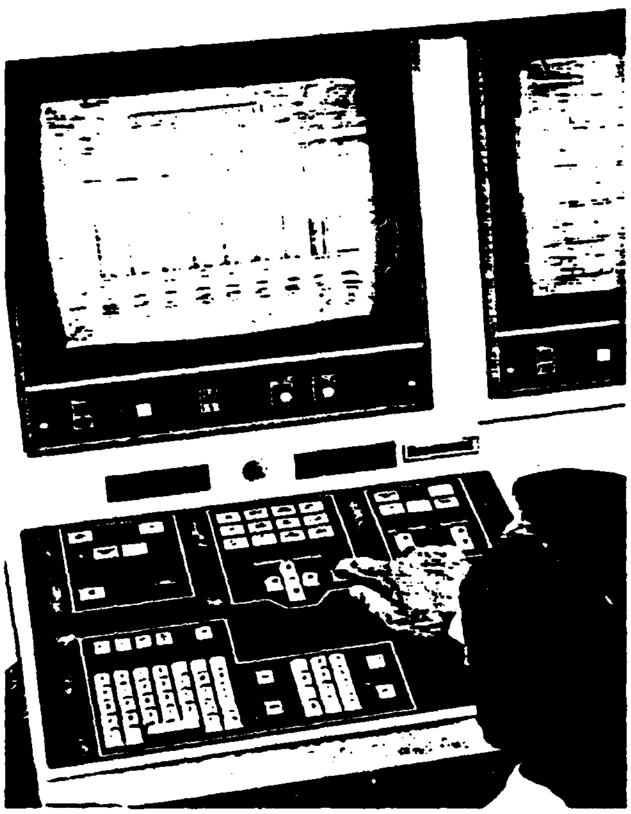
To keep the Operator's attention focused on key variables and help him maintain a proper perspective on overall process operation.



PROCESS LEVEL
50 Overviews

AREA OR GROUP LEVEL
200 Groups

LOOP LEVEL
All continuous and logic loops



DISPLAY ORGANIZATION

The Model 25 VDS Operating Displays give an operator an overview of a major process area - up to 45 continuous and discrete variables - on a single display. Variables can be grouped to suit your objectives, so the operator's attention can be drawn to those indications that really transmit the pulse of the process.

He can easily step from the overview directly to a group display to get a closer look at up to 9 variables or control loops. Here he can adjust setpoints or other parameters, and quickly take manual control, when necessary, in an emergency.

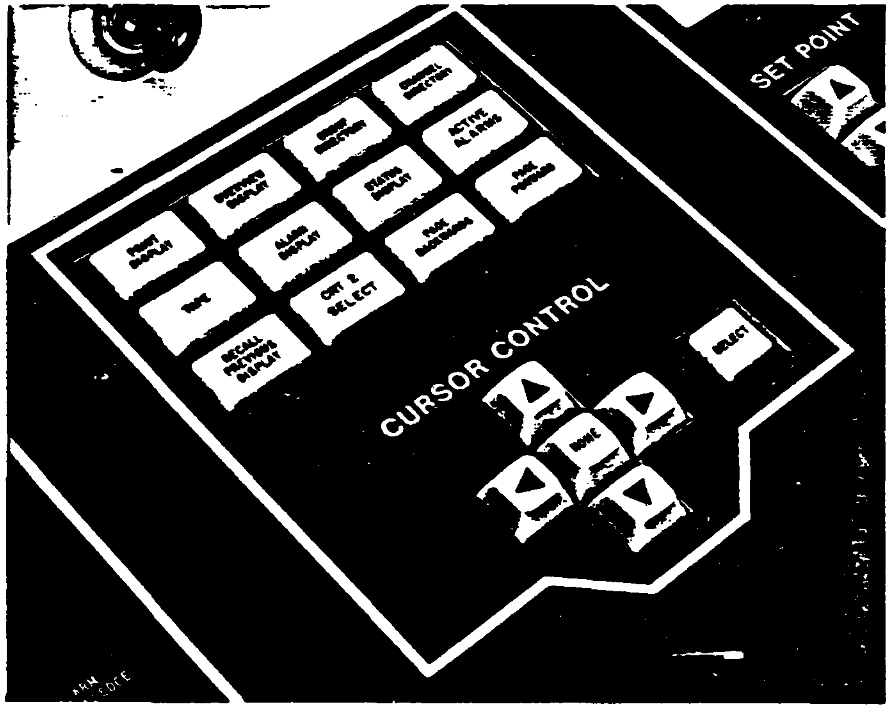
A press of a button will take him to the lowest level in the hierarchy, where he can check any detail of an individual loop, such as tuning constants or alarm settings.

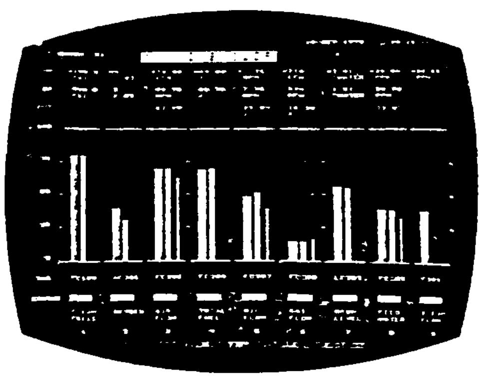
The system has been designed to always anticipate the operator's next move. In most cases, he can call up the display he wants with a single push of a button. And yet the keyboard is simple and uncluttered, eliminating the need to hunt for the right button.

D. Rosemont – Diogenes

BETTER DISPLAY OF OFF-NORMAL AND ALARM CONDITIONS —

To help an Operator respond swiftly and systematically to major upsets and emergencies.





ALARM DISPLAYS

Process alarm messages, regardless of the source of the problem, are vividly displayed to the operator upon occurance right in his normal field of view. Regardless of what display he happens to be looking at, the system will alert him immediately, and tell him exactly what the problem is and where. A single push of a button takes him immediately to the troubled loop.

The system keeps a running record of all alarm occurances which an operator can view at any time. Now the day shift can tell exactly what troubles occurred on the night shift, and can be better prepared to deal with them. What's more, that record, which preserves both the sequence and duration of alarms, can be printed at any time for later analysis by process troubleshooters.

E. Beckman

MV8000

MV 8000 PROCESS CONTROL SYSTEM

Combines hybrid analog/digital circuitry for single loop control and shared microprocessor digital technology with distributed systems architecture and centralized operations.

Single loop hybrid analog/digital control
- Wide application suitability–large and small plants/processes
- Modular construction for simple expansion and function changes
- Easily adapted to DDC, supervisory control and ASCII/RS232C communications
- Up to 63 single loop controllers on a single hiway

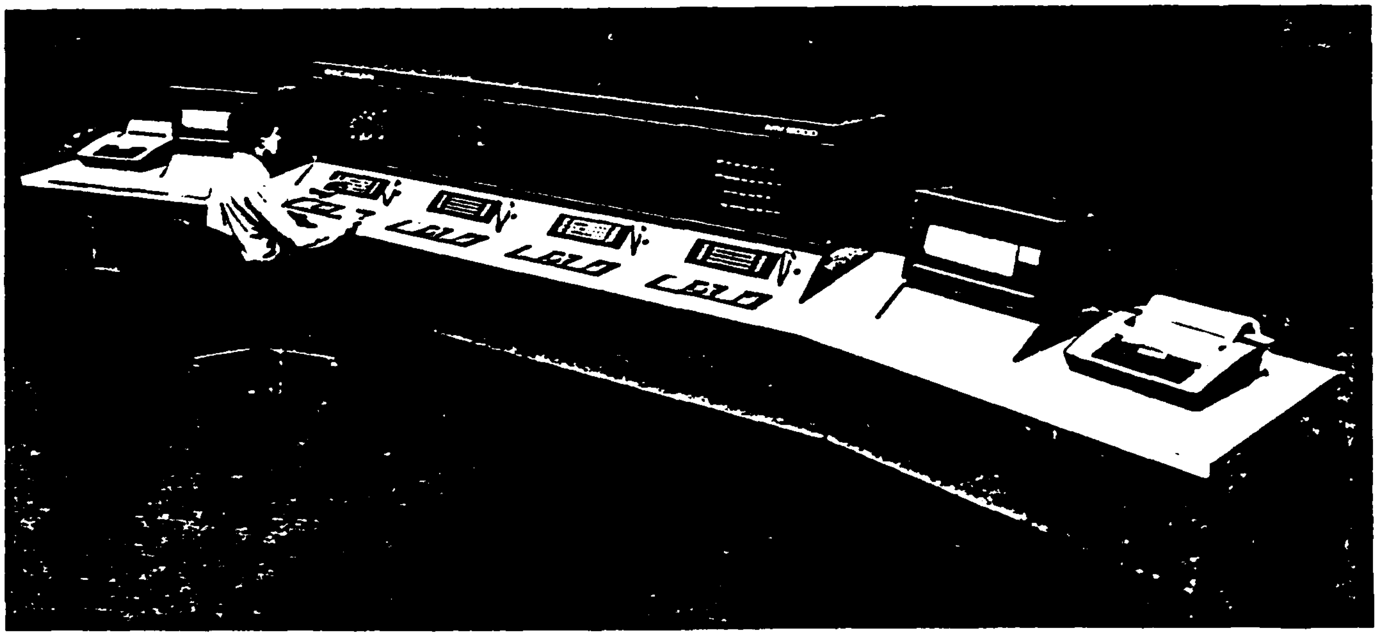
Multiple-loop digital processing
- Standard controller for continuous and batch applications
- Self-redundant–retains full automatic control under malfunction/failure conditions
- Controller processing capability of 40 selectable algorithm functions
- Up to eight multi-variable control units on a single hiway

ASCII/RS232C Communications
- Permits single-loop, multi-loop or hybrid combinations to interface with CRTs, PLC's, host computers, and data acquisition devices
- Up to 16 redundant data hiways–up to 5000' (1524m) long.
- Supports up to 750 analog and digital control loops

Expanded graphic displays
- Generated by system microprocessor software on 19" CRT screens
- Up to 99 eight-color dynamic interactive displays–activated by operator keyboards or light pen
- Permits operator manipulation of control loops

Beckman's evolutionary MV 8000 combines hybrid analog/digital circuitry in a variety of configurations to offer the most advanced distributed process control system available today. From the simple, single unit process to the most complex plant operation, Beckman's system concept provides the flexibility to meet the most stringent application requirements. The most versatile system available, MV 8000 offers configurations to fulfill application safety and plant availability requirements at the most cost-effective level.

The MV 8000 incorporates the most advanced technological innovations into a unique system design. Its engineering excellence is combined with maximum hardware versatility, resulting in the ultimate control system–**Beckman's MV 8000.**



5

E. Beckman MV8000

MULTI-VARIABLE CONTROL

Combines microprocessor digital electronics and distributed control with optimum functionality and on-line reliability.

- One basic controller
- For continuous and batch control
- Self-contained redundancy for retention of full automatic control under malfunction or failure conditions.

The Multi-Variable Control Unit (MVCU) features a single standard digital controller to cover the entire spectrum of process control strategy. From conventional PID algorithms, to complex computational equations developed in ready-to-use software or for definition in custom applications. The MVCU may be applied to continuous processes and batch/sequential logic at a cost effective level without compromising plant availability during a system malfunction.

- —32 analog inputs
  - 1-5 volts
  - 4-20 ma
  - Thermocouple
  - RTD
- —16 analog (4-20 ma) outputs
- —32 digital inputs/32 digital outputs

ALGORITHMIC FUNCTIONS

Include the following standards:

GROUP I
PID Algorithms

PI	Proportional plus Integral
I	Integral only
PID	Proportional plus Integral plus Derivative
P + Bias	Proportional only with Bias
PD + Bias	Proportional plus Derivative

GROUP II
PID Algorithms with Error Squared on Gain
PI
PID
P + Bias
PD + Bias

GROUP III
PID Algorithms Ratio
PI
I
PID
P + Bias
PD + Bias
A. Limits
1. Setpoint limits
2. Output limits
a. Adjustable (program settable)
b. Adjustable (continuously for override)
B. Preprogram Control
1. Static Fail
2. Dynamic Fail

GROUP IV
Auxilliaries
A. Ratio Station
B. Manual Loader
C. Automatic/Manual Station
D. Indicator Stations
E. Totalizers

GROUP V
Computational Blocks
A. Adder/Subtractor
B. Multiplier
C. Divider
D. High Selector
E. Low Selector
F. Square Root
G. Square
H. Function Generator
I. Lead/Lag

GROUP VI
Analog to Digital Function Blocks
A. Process Alarm (high or low)
B. Deviation Alarm (high or low)
C. Rate of Change Alarm
D. Compare
E. Ramp Generator
F. Integrator

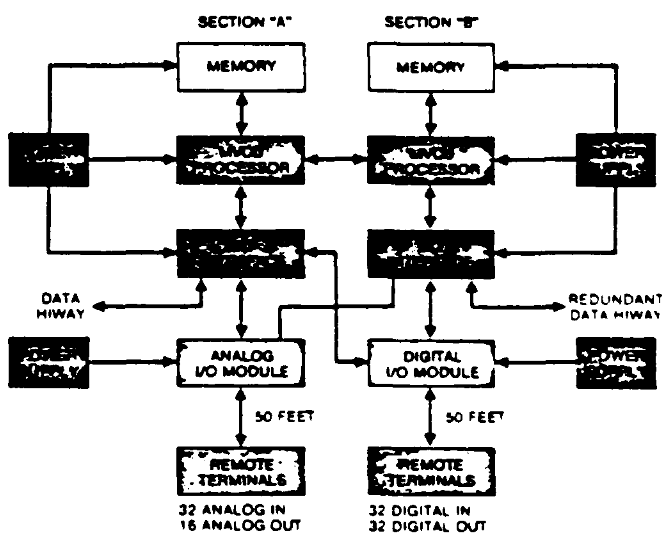
GROUP VII
Digital Function Blocks
A. Logical AND
B. Logical OR
C. Logical NOT
D. Counter
E. Timer (local)
F. Timer (time of day)

GROUP VIII
Digital Control Blocks
A. Master Control Relay
B. Control Relay
C. Output Relay

CONTROL REDUNDANCY

Retention of full automatic control under malfunction or failure conditions is inherent to the Beckman MVCU design. In normal operation, section "A" has control, while a duplicate section "B" tracks. Any deviation from normal sensed through diagnostic monitoring will instantaneously transfer section "B" from a tracking mode to full control.

A transfer state is unobserved by the process, but is annunciated through the system for maintenance correction.



CENTRAL OPERATIONS IN A DISTRIBUTED CONTROL SYSTEM

THE OPERATOR INTERFACE

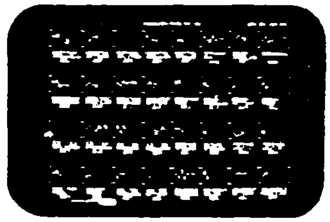
The MV 8000 operator interface is more than a convenient CRT window on the process. It replaces the conventional panel board with massive analog displays – controllers, indicators, recorders, counters, switches, lights and annunciators and organizes the information to increase operator efficiency. More significantly, it provides the means to track off-normal conditions, selectively react to levels of alarms, logically diagnose fault conditions, move to quickly correct upsets, and thereby maintain product integrity and plant availability.

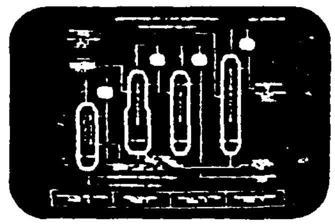
The operator center is the core to a distributed control system and is configured to provide a high level of redundancy. Composed of a CRT and keyboard, each functions independently and can back-up the other in the event of a failure.

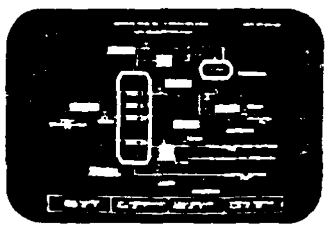
Operator consoles are designed to standard arrangements to satisfy the requirements of small, medium and large process installations. The minimum recommended configuration would comprise two CRT stations, while three or even four should be considered as a means to provide flexible control in demanding environments. In a three station system, it is practical to dedicate the displays to:

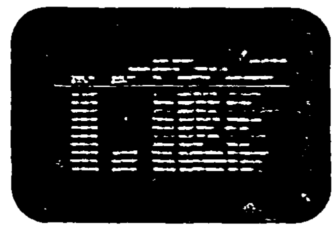
- plant deviation overviews
- plant graphic overviews
- alarm

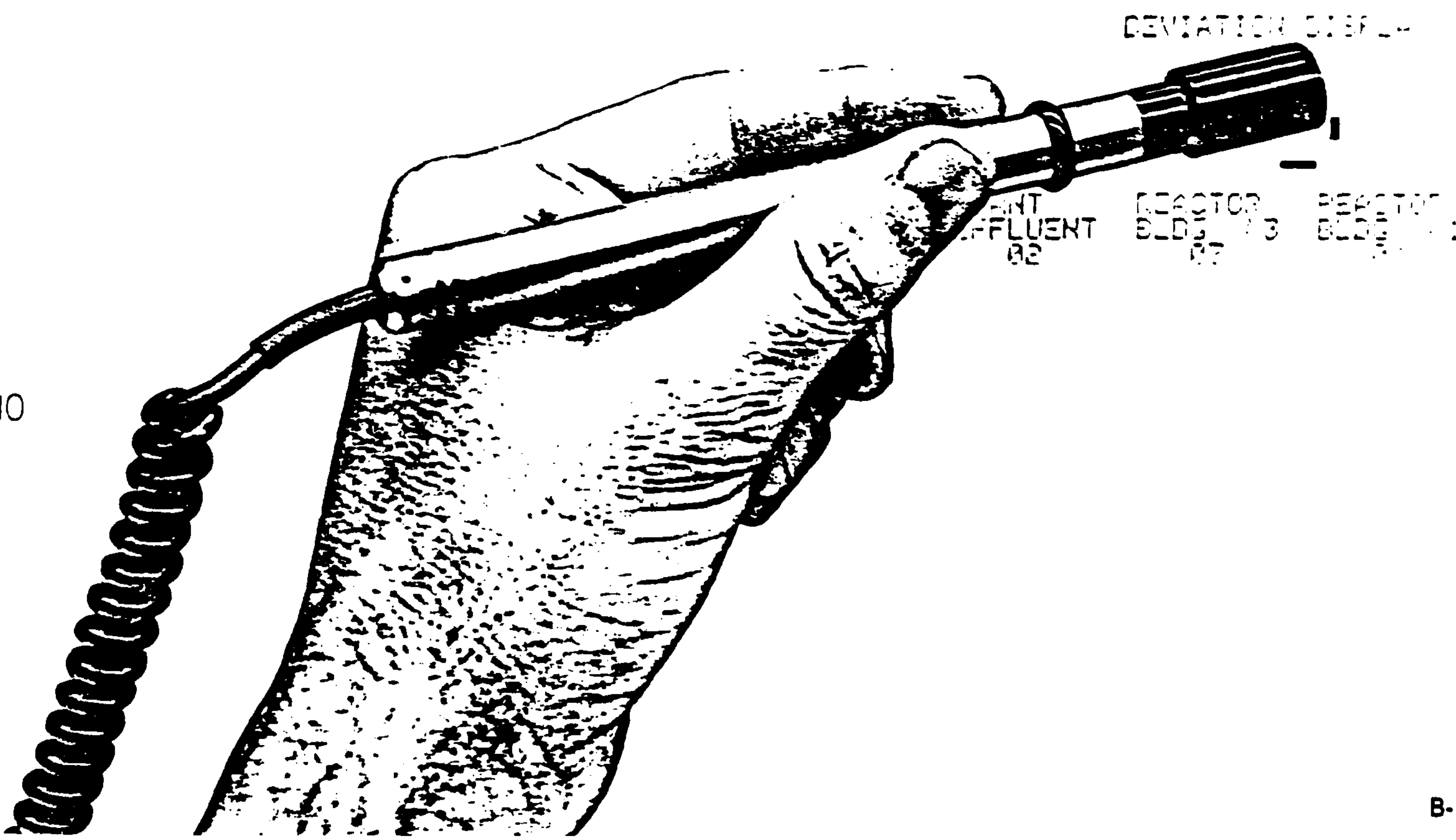
If a fourth station is added, it would likely be used for additional displays to the many levels available in the Beckman MV 8000 System.


Deviation Overview


Plant Graphic Overview


Graphic Detail


Alarm Summary



Beckman **MV 8000**

ə Beckman MV 8000 offers an almost unlimited
nbination of displays, convenient to normal
erations or during process upsets.

ANT OVERVIEW

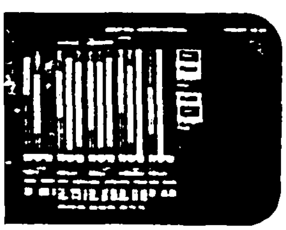
th a system capacity of 750 analog or digital points,
nt overview is expanded to four pages at
5 points per page for optimum operator moni-
ing. Display format is in deviation which permits
ıdy scanning of process variables with respect
set point and alarm limits.

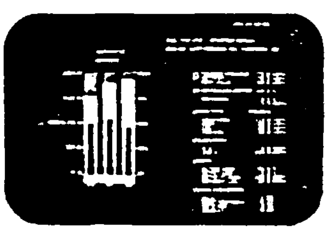
IOUP DISPLAY

'iables in overview are assigned into groups of
ht by association in a given process–for example:
phtha Splitter. In a group display, it may be viewed
individual tag and title with setpoint, process
'iable and valve position displayed in bar-graph
mat with associated alpha-numeric values in
gineering units. Digital points-stop/start circuits,
:.–are shown as color coded boxes.

ə operator manipulates any loop from the
/board including:
- set point
- auto-manual switching
- slow or fast manual valve output adjustment
- on-off switch of digital outputs

auxiliary "Group Alarm Summary" display itemizes:
- individual loops by tag and title
- alarm status


Group


Loop Detail

OP DETAIL

oop detail display may be activated at any time
d manipulated in the same manner as at the group
el. However, detail is enlarged and loop charac-
istics including tuning constants are shown in
ıha-numeric symbols. For increased flexibility, a
ıp may be configured into any group.

TREND

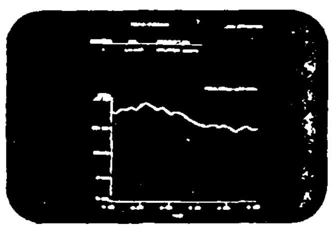
All primary analog process variables up to the system maximum of 750 may be displayed for historic and real time trend.
- 500 minutes history based on one minute samples for five minute averages
- 25 hour history based on one minute samples for 15 minute averages

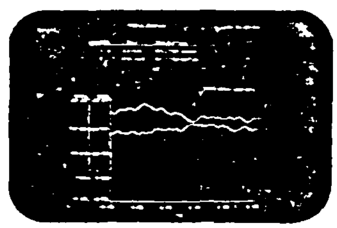
A 100 variable fast trend is also standard.
- 10 minute history based on six second samples
- 100 minute history based on six second samples for one minute average.

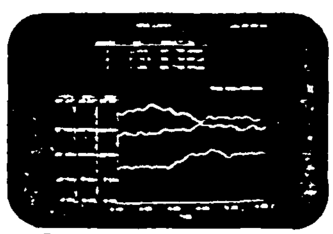
Trend memory is retrievable at the group, loop and graphic level, and configured as normal or fast through the trend detail display. The operator may exercise his option to view up to any four loops with a selectable time base. Scale ranges are displayed in their respective engineering unit values.

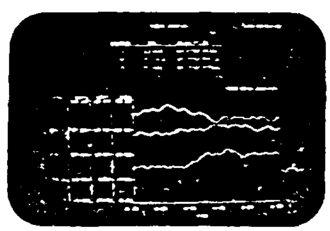
Trend displays may be free formatted (up to four loops) for any loop in the system by calling up its tag identification.

Each trended variable will be updated in real time at the rate of the selected sample average.


Trend 1

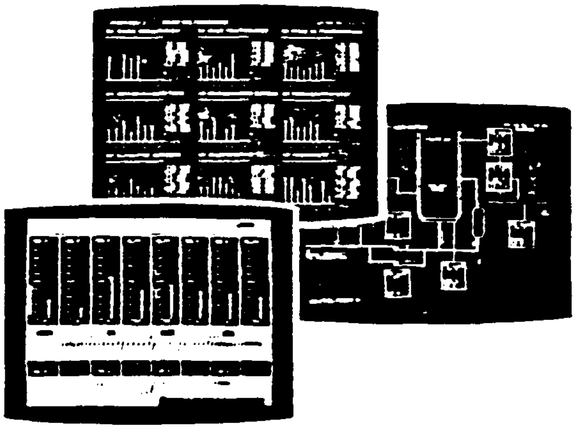

Trend 2


Trend 3


Trend 4

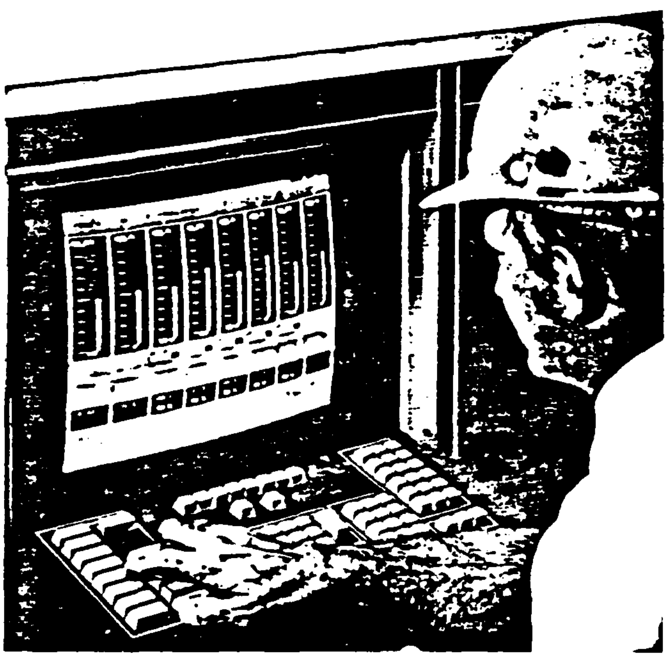
F. Moore Products—Mycro

FEATURES



MORE EFFECTIVE DISPLAYS

The Moore overviews allow the operator to note where each process variable is with respect to full scale and with respect to its setpoint and alarm settings. They also identify tag numbers for each loop. Overview displays available to date have been generally ineffective except to identify that an alarm exists in some group. Group displays mimic control station faceplates which are thoroughly familiar to an operator. Point displays include real time recording of the variable and, upon operator selection, the valve signal recording is added. Graphic displays allow control from real time data blocks. Trend displays allow great flexibility in changing scale amplification, and time base, and permits scrolling.



EASY, ONE-KEYSTROKE OPERATION

The MYCRO operator keyboard has a simple, logical layout allowing fast, confusion-free operation. A valid criticism of contemporary CRT keyboards is that the operating procedure can get confusing and time-consuming especially during emergencies, start-up, shutdown and periods of upset or change in processing operations. The MYCRO system employs an intelligent keyboard whose microcomputer performs an evaluation routine which permits it to anticipate the desires of the keyboard operator and allows him to perform most of his moves by means of a simple and logical one-keystroke operation. The keyboard computer also quickly invalidates unauthorized keystrokes.

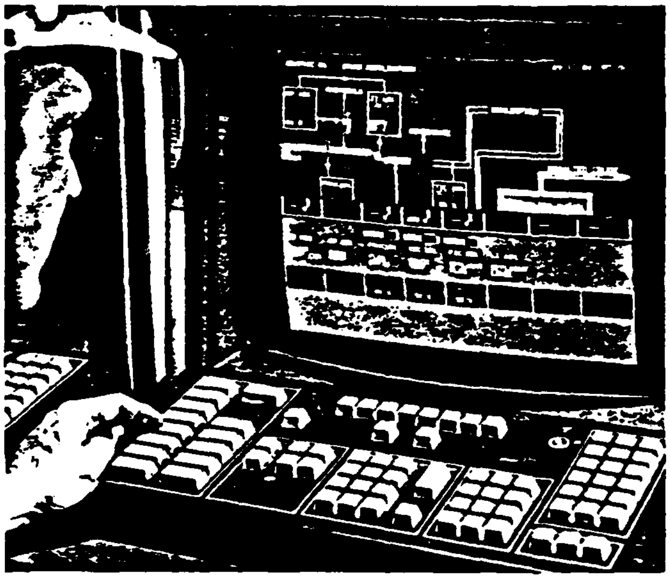
F. Moore Products–Mycro

FAST RESPONSE ON CHANGE IN DISPLAYS

It is very frustrating to an operator and possibly even hazardous, especially during emergencies, to call up a new display and then be required to wait sometimes as long as 30 seconds, or even minutes, for the new display to be developed on the screen. The delay results either because the digital data is slowly serially transferred or because a higher level program transmits the data.

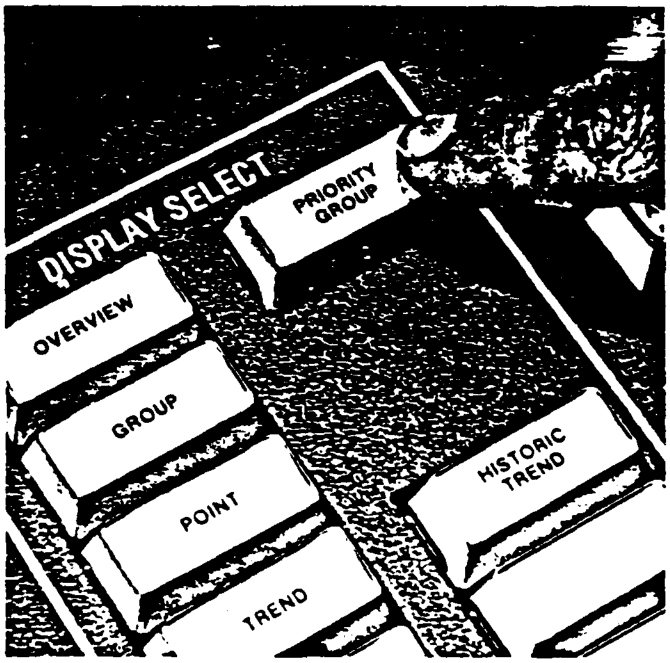
In the MYCRO system backgrounds for all but the graphics displays are stored in ROM in the CRT and the data is transferred over the internal data bus in approximately a half-second. Graphic displays are stored on disk and generally appear in 1 or 2 seconds when called up by the operator.

Rea' time data is refreshed every half-second.



PRIORITY GROUP PUSHBUTTON

During conditions of widespread process upsets or emergency, resulting in multiple alarms, the operator can become confused as to which loops to concentrate upon. In such situations , the operator can push a priority group button which will display loops previously configured into groups according to their priority of importance in maintaining the plant on-line and in helping restore it to normal. By sequencing the Priority Key, the operator is guided, loop-by-loop, to an orderly restoration of normal control—or a shutdown, if critical loops cannot be brought under satisfactory control.



F. Moore Products–Mycro

NOVEL, EASY-TO-USE GRAPHICS PACKAGE

This unique system which generates comprehensive, real-time graphic displays operates from a program stored on disk. There is no programming and no fill-in-the-blanks procedure required on the part of the user—and no extra computer is involved. The hardware consists of a plug-in graphics plotter board and a cursor control pen (Fig. 1). The plotter board is divided into coordinates which relate directly to coordinates on the video screen. The lower portion of the plotter board is divided into blocks displaying standard process symbols, blocks for selecting background and foreground colors, various line modes and an erase mode of operation (Fig. 6). Movement of the cursor control pen on the plotter board is duplicated on the video screen. Pressing the cursor control pen to the plotter board fixes the cursor position on the screen, and selects a color, symbol, line, or erase mode of operation.

Placing a symbol on the graphic simply requires the user to first select the foreground and background colors by pressing the cursor control pen to the appropriate blocks. He then selects the point where he wants the symbol to appear by pressing the cursor control pen to the appropriate coordinate on the plotter board. Next he presses the cursor control pen to the appropriate symbol block which then makes the symbol appear on the screen. Lines are constructed by pressing the cursor control pen to the type of line mode preferred (e.g. single or double thickness, pipe, diagonal) and then pressing the pen to the plotter board to locate the beginning and end points of the line. This makes the line appear instantly. The erase mode permits removing any portion of the graphic by using the cursor control pen as one would an eraser. Alphanumerics are positioned with the cursor control pen and inserted by means of the configuration keyboard. Real time data blocks (a data block is one of the standard available symbols) can be inserted in any graphic. These display such data as process variable, setpoint, output and controller status. The operator can manipulate control loops in the on-line graphic mode.

Sketch pads (Fig. 2) which duplicate the plotter board face, and a template sheet which duplicates the standard symbols, allow a user to sketch a graphic first (Fig. 3). By superimposing the sheet onto the plotter board (Fig. 4), the user quickly generates his graphic by essentially tracing the sketch through appropriate manipulation of the cursor control pen (Fig. 5).

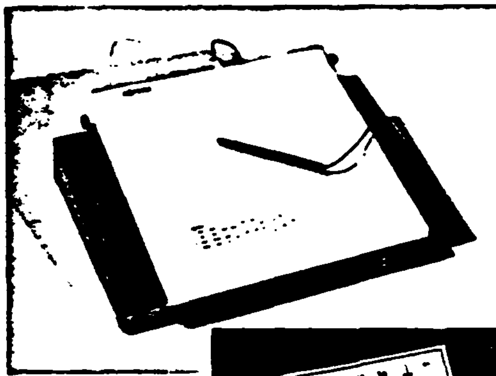


FIG. 1

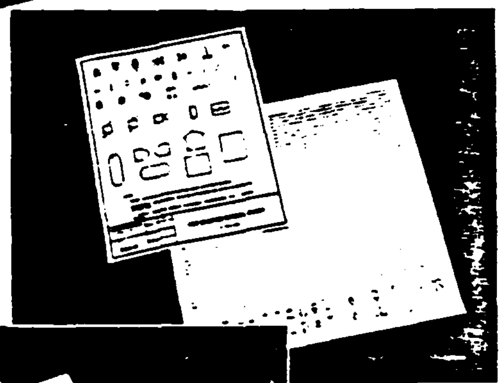


FIG. 2

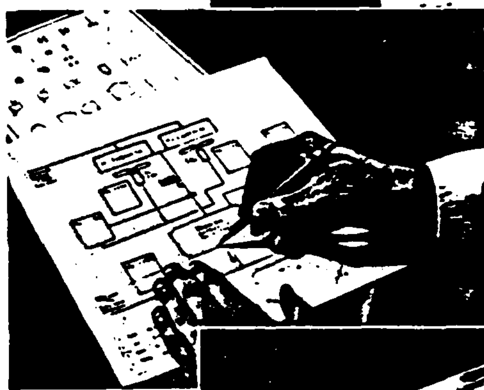


FIG. 3

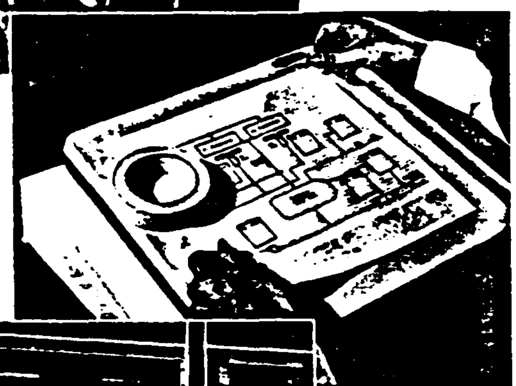


FIG. 4

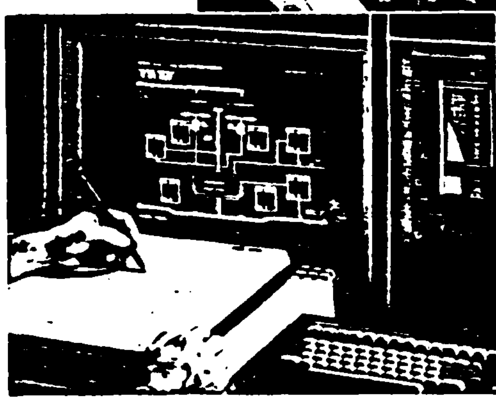


FIG. 5

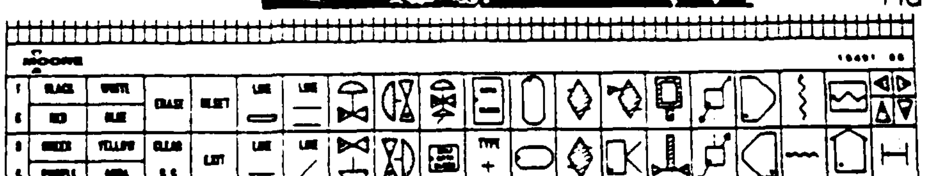
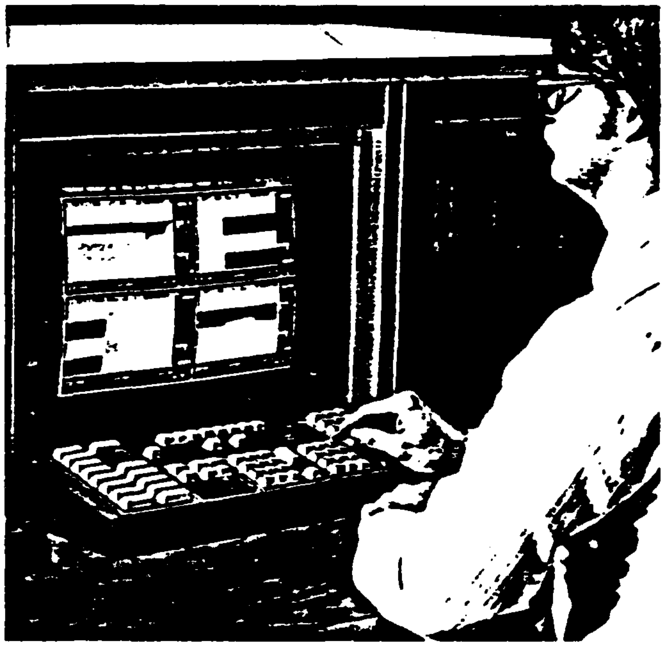


FIG. 6

F. Moore Products–Mycro



Up to 192 system points can be trend recorded on the dual redundant disk memory system. Disks can be stored for future reference as each becomes fully loaded.

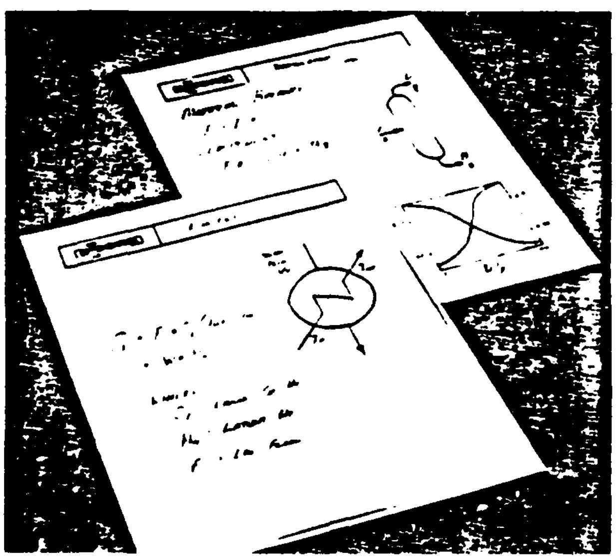
A trend display covers four (4) points (a half-group) with one point in each quadrant. A short-term trend allows the operator to view the immediate past 64 minutes of data. Long-term trend allows him to display any data recorded on an inserted disk.

With the pushbuttons, the operator can amplify the scale, change the time base, and scroll the recording, right and left. As the recording trace intercepts the vertical scale coordinate, an accurate readout of the intercept appears on the screen. Any recorded value, therefore, can be displayed by scrolling the trace. The operator can also temporarily change which four points appear in any trend display by substituting any of the other trend recorded points into the display.

HARD-COPY ANALOG RECORDING

By keyboard operation, any of the configured points in the system can be connected to any of up to 32 recording pens on conventional analog recorders. The selected digital points in the data base are converted to 1 to 5 Vdc analog signals for recording.

This system serves the function of a giant trend-recording patch panel.



CALCULATION PACKAGE

Functions such as efficiency, yield, and process economic indicators can be computed and displayed by means of a 32-bit floating-point calculator. Operators include addition, subtraction, multiplication, division, square-root, exponential, filter, Log, Ln, absolute, integrate, average, timing, and logic.

G. Texas Instruments – PM 550

PID Loops

The PPC also executes all PID loops on a time-share basis. PID calculations are updated every 0.5 to 4095 seconds. This execution time is programmable.

In establishing PID loop criteria, certain areas of V and C memories must be set aside to store loop parameters and I/O data. There are two such areas required for each loop; these are referred to as the V and C tables. The first memory location of each table is specified when programming each loop. The loop programmer then displays the ending address of each table. There are three parameters, called tuning constants, that may be located at the end of either table. Their location is also determined during programming. The basic C table requires only 14 words, and the basic V table requires 11 words. The three tuning constants require an additional six memory words, but they may be located at the end of either table.

C TABLE

0	LOOP NO — SAMPLE RATE
1	C TABLE FLAG WORD
2	SPECIAL FUNCTION ADDRESS
3	PROCESS VARIABLE ADDRESS
4	SETPOINT ADDRESS
5	OUTPUT ADDRESS
6	PROCESS VARIABLE
7	SPAN
8	PROCESS VARIABLE
9	LOWER RANGE
10	LOW ALARM LIMIT
11	HIGH ALARM LIMIT
12	YELLOW DEVIATION LIMIT
13	ORANGE DEVIATION LIMIT
14	ADDRESS OF CR BITS FOR LOOP
15	PROPORTIONAL GAIN,
16	K_C
17	RESET COEFFICIENT,
18	$K_C T_S/T_I$
19	DERIVATIVE COEFFICIENT,
20	T_D/T_S

V TABLE

0	LOOP NO — SAMPLE COUNT
1	V TABLE FLAG WORD
2	PROCESS
3	VARIABLE
4	SETPOINT
5	
6	ERROR
7	
8	OUTPUT
9	
10	BIAS
11	
12	PROPORTIONAL GAIN,
13	K_C
14	RESET COEFFICIENT,
15	$K_C T_S/T_I$
16	DERIVATIVE COEFFICIENT,
17	T_D/T_S

In addition to the loop tables, each loop may have 10 loop flags or image register bits (IR bits). Again, the first IR location (Y or CR) is specified and the next nine locations are assumed. The first three IR locations are used by the ladder logic to switch the mode of control of the loop, whereas the last seven locations are alarm status bits and may be used in ladder logic for control or alarm status.

IR BITS ASSOCIATED WITH LOOPS

LOOP FLAGS

BIT	SET BY	MEANING OF 0	MEANING OF 1
1	CCU	Not requesting manual mode	Requesting manual mode
2	CCU	Not requesting auto mode	Requesting auto mode
3	CCU	Not requesting closed cascade	Requesting closed cascade
4	Loops	Loop is in manual	Loop is in auto
5	Loops	Loop is in open cascade	Loop is in closed cascade
6	Loops	PV is not in high alarm	PV is in high alarm
7	Loops	PV is not in low alarm	PV is in low alarm
8	Loops	Negative error deviation	Positive error deviation
9	Loops	Deviation is not in orange band	Deviation is in orange band
10	Loops	Deviation is not in yellow band	Deviation is in yellow band

Diagnostics and Auxiliary Functions

In addition to the normal modes of operation, the TMS9900 (the PPC) may be called upon to perform certain diagnostic or special tasks called auxiliary (AUX) functions. These AUX functions should not be executed during normal execution of an application program since they are not included in the normal execution scan of the PPC. Execution of the AUX functions should be done by switching the CCU from RUN to STARTUP. The status of the CCU (RUN or STARTUP) will also be indicated by the read/write programmer (RWP) when the red CLR key is depressed.

AUXILIARY FUNCTIONS

Aux. 1 Clear memory

Aux. 2 Program mode/single scan

Aux. 3 Programmer self-test (diagnostic)

Aux. 4 CCU self-test (diagnostic)

Aux. 5 Read/clear error table (diagnostic)

Aux. 6 Tape control (STR-Link II)

Aux. 7 Entering ASCII message

Aux. 8 Program printout

Read/write programmer

G. Texas Instruments-PM 550

Operator Interfaces

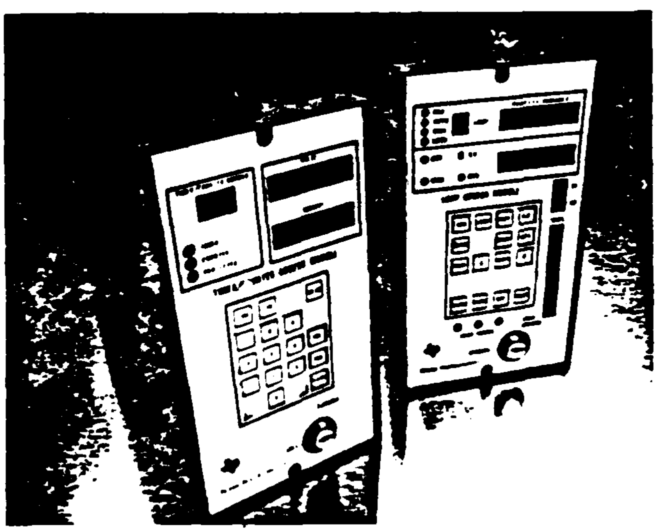
Loop Access Module (LAM)

The remote operator devices mentioned earlier are the loop access module (LAM) and the timer/counter access module (TCAM). Both can be located up to 304.8 meters (1000 feet) from the CCU, and they communicate over an RS422 (differential line) at 9600 baud. These modules are designed to be mounted in harsh industrial environments; each has a diaphragm faceplate to seal out oil, water, and dirt.

The function of the LAM is to display all appropriate process loop parameters at a remote location. The LAM displays the process variable in the upper window. The lower window displays the output, setpoint, bias, deviation, or tuning parameter (gain, rate, reset) whenever the appropriate button is pushed. All these parameters can be modified by the increase ▲ or decrease ▼ key. A FAST mode key is also provided for use in conjunction with these keys. The LOOP key steps the LAM to the appropriate loop to be displayed.

The process variable HI and LO alarms and the yellow/orange deviation alarms are entered during programming. These alarms are displayed by the LEDs on the right side of the LAM. The mode of operation (MAN, AUTO, CAS) is also indicated by LEDs located at the upper left of the faceplate. The particular tuning constant in the lower display is indicated by an LED under the appropriate button (GAIN, RATE, RST).

The key switch allows the operator to lock out certain features of the loop once that loop has been programmed. In the monitor mode, the changing of tuning parameters is inhibited. The setpoint and mode of operation may be locked out if so requested during the programming of a loop. If more than one loop needs to be displayed continuously, up to eight LAMs may be daisy-chained to display all eight loops simultaneously.



Loop access module (LAM) at right, timer/counter access module (TCAM) at left

Timer/Counter Access Module (TCAM)

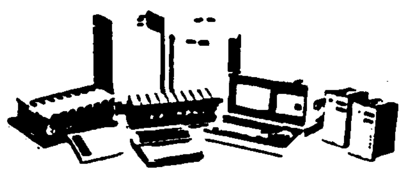
The TCAM is a remote operator device that allows timer and counter parameters to be modified at locations up to 304.8 meters (1000 feet) from the CCU. The TCAM is drip-proof and dust-proof because the unit's front panel is sealed.

Preset and current words of both timers and counters can be displayed and adjusted with this unit. A TCAM can address the first 99 timers or 99 counters one at a time. To read the preset and current word in a timer or counter, the operator merely selects either TMR or CTR on the TCAM faceplate and selects the timer or counter number. This number shows in the two-digit display. When the READ key is depressed, the current and preset words will be displayed. After selecting a timer or counter, the preset word may be modified by pressing the PRE key and entering the appropriate value. This new value then shows in the upper display. Once the operator has the preset information displayed, he may press the ENTR key to enter the new data. The current word may be modified in a similar manner.

As with the LAM, all modification features may be disabled by prompting and locking out the module with the key switch. With the PM 550 system, the only limit to the number of timers and counters is the size of memory, since each timer or counter requires two words of either V or C memory in which to store the current and preset values; however, the TCAM displays only the first 99 counters or the first 99 timers. If more than one timer or counter needs to be displayed, up to eight TCAMs may be daisy-chained for simultaneous display.

Note: CRT operator stations are now available from T-I for use with this system. They are available with disc or bubble memory.

G. Texas Instruments- PM 550



This discussion of a boiler combustion control system is based on an actual application in which the customer required two functions from a Texas Instruments Program Master 550. The PM 550 was used both for combustion control and as an energy management data acquisition device reporting to a central computer. In addition, the customer was able to read out instantaneous boiler efficiency so that the operator could make trim adjustments for optimization. This application demonstrates the PM 550's capability as a double or even triple function device.) The following approach was developed by Applications Engineering Distributor Andrew Wiktorowicz, president, Automated Dynamics Corp., Tustin, CA, 714/838-7640.

The basic purpose of boiler combustion is to regulate steam header pressure by controlling the flow of fuel and air into the furnace. Steam header pressure is the primary demand sensor for most boilers and it varies with the boiler load. A P&I algorithm determines firing rate and transmits this rate to the boiler masters (where multiple boilers feed a common steam header). The boiler masters proportion demand to adjust the boiler firing rate so that each boiler assumes the proper load balance (selected by the operator). This signal is used to set the air/fuel ratio and in turn air and fuel flow setpoints.

Air/Fuel Flow Controls

When boiler firing rate demand changes upward, fuel flow must be increased simultaneously in order to maintain the air/fuel ratio within safe limits. Otherwise, the difference in system dynamics between air flow and fuel flow controls could result in inefficiency, flame extinction, or, in extreme cases, boiler explosion. Therefore, fuel/air cross limiting is essential for both increasing and decreasing firing rate demand signals, to assure some excess air at all times.

The fuel flow controller receives a setpoint demand signal which is the lower of firing rate demand and air-limit-to-fuel. The controller compares this signal with the actual fuel flow (after square root extraction). The results of the P&I algorithm are the output to the fuel valves.

The air flow controller receives its setpoint from the greater value of firing rate demand and fuel-limit-to-air signal. This, along with the cross limiting on fuel flow, ensures that fuel flow decreases before air flow and that air flow increases before fuel flow. The air flow controller compares this setpoint with the actual air flow (after square root extraction). The results of the P&I algorithm are the output to the air valve.

If a change in the firing rate demand signal is less than the difference between the output signals of the two bias and gain computations, the firing rate demand signal is provided in parallel as the remote setpoint to the air flow controller. Thus, bias and gain computations give an operating margin, by using a small percentage of excess air, and allow the boiler to respond rapidly to small percentage load changes without operating within the fuel/air cross limit constraints.

Air/Steam Flow Correction

The air flow/steam flow correction, which automatically compensates for fuel BTU variances, is based on control of the ratio of air flow to steam flow, since BTU output is proportional to BTU input. Total air flow correction is accomplished by the equation

$$\Phi = X_1 + X_2(Y - 0.5).$$

The total air flow process variable (linearized through square root extraction) is provided to the low limiter (an arbitrary air flow low limit) and to the summer (Σ). The multiplier (X) receives the process variable inputs of total air flow (with the arbitrary minimum) and the output from the oxygen controller.

The process variable input signal to this controller is the steam flow, which has been characterized for the boiler load range. If the output signal from the oxygen controller equals 50%, the summer does not correct the air flow signal. If the output is greater or less than 50%, then the ratio controller corrects the output to the multiplier and the summer corrects the air flow process variable signal.

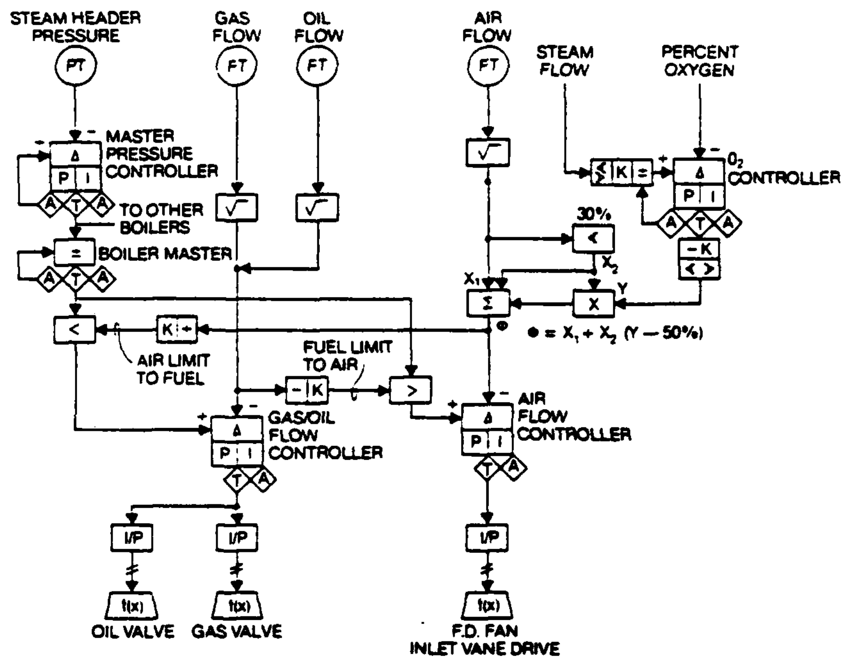
The limiter ($<$) and multiplier correct proportional air flow when actual air flow is above 30% or some other fixed minimum of the total available air flow. A bias correction is made when actual air flow is less than 30% of the total available air flow.

The O_2 correction automatically readjusts the fuel/air ratio, depending upon the oxygen content of the flue gas stack. The O_2 setpoint is computed as a function of boiler load (steam flow). Thus the O_2 controller provides the basic P&I control algorithm described for air flow/steam flow correction.

For more information about how the PM 550 can benefit the boiler combustion control system in your facility, call Texas Instruments at 615/461-2501 or write Texas Instruments Incorporated, Industrial Controls Marketing, PO Box 1255, Mail Station 3516, Johnson City, TN 37601.

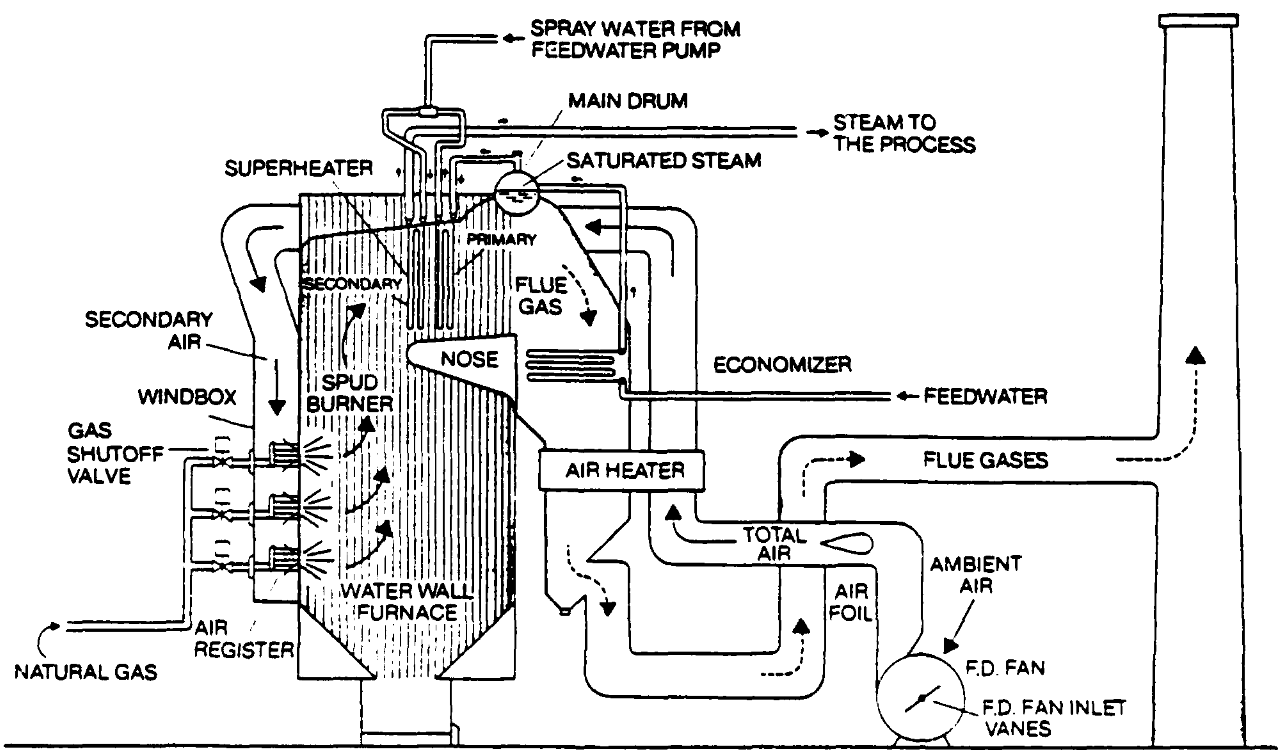
G. Texas Instruments PM 550

Gas/Oil Combustion Control with O_2 Correction



In addition to fuel flow control and air flow control, boiler combustion control includes: fuel/air cross limiting for increasing and decreasing firing rate demand signals, air/steam flow correction which automatically compensates for fuel BTU variances, and O_2 correction which automatically adjusts the fuel/air ratio depending upon oxygen content of the flue gas stack.

Typical Gas-Fired Boiler

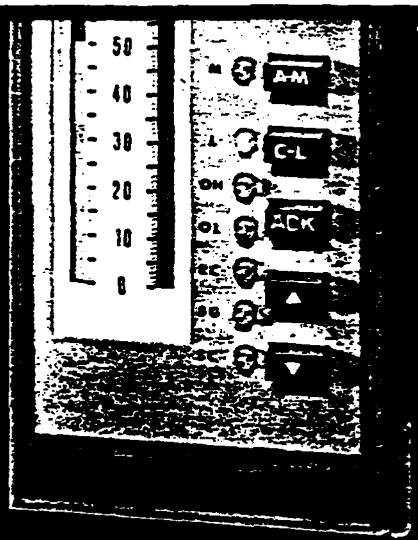


Steam header pressure is the primary demand signal for most boilers. This demand signal not only determines boiler firing rate but is also used to set air/fuel ratio and in turn air and fuel flow setpoints.

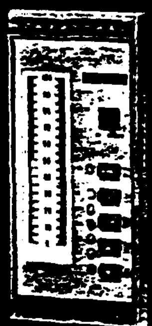
...objectives, so the operator's attention can be drawn to those indications that really transmit the pulse of the process.

the display he wants with a single push of a button. And yet the keyboard is simple and uncluttered, eliminating the need to hunt for the right button.

H. Robertshaw DCS-1000



The Robertshaw DCM-1000/1500 series digital control modules (DCM'S) are intelligent, stand-alone, process controllers. The DCM'S are microprocessor based and include features not found in other controllers currently available. They are housed in conventional three (3) inch by six (6) inch instrument chasis.



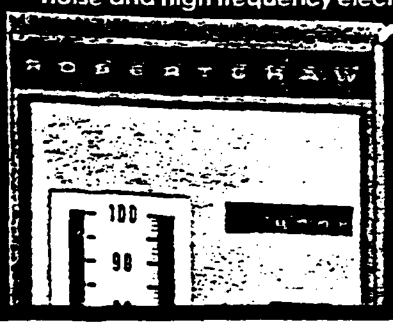
The basic DCM is equipped with a dual bargraph display that continuously indicates both the current value of the process measurement and the setpoint. A digital display is provided with a three (3) position selector switch to display either the process measurement, the control output, or the setpoint (in engineering units). There are also remote setpoint input options for cascade control applications.

The DCM is programmed to check eight alarm conditions, to execute three (3) basic control algorithms, and communicate on a multi-drop communications bus along with other modules of the DCS-1000 family.

The complete instrument consists of plug-in circuit boards that allow easy replacement of a defective component...to minimize down-time. A built-in manual back-up station is included to facilitate maintenance procedures.

The total instrument is housed by a single chassis and is completely self-contained.

An isolated power supply for the transmitter is provided and the voltage to frequency (V/F) input conversion techniques employed in the analog to the digital (A/D) section of the instrument provide INFINITE rejection of 50/60 hertz electrical noise and high frequency electrical noise. This eliminates the need for special field wiring typically found in digital control systems.



H. Robertshaw DCS-1000

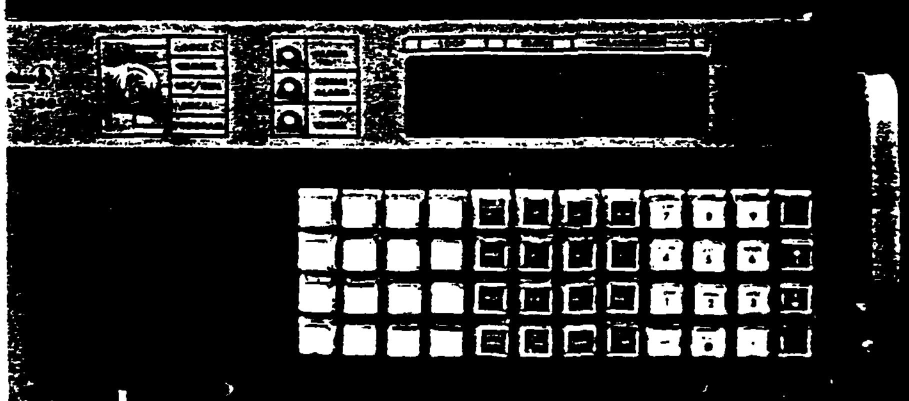
DSM-1500

The Robertshaw DSM-1500 digital supervisory module (DSM) is a special purpose microcomputer intended for use in conjunction with the other elements of the DCS-1000 family of control modules. The DSM is preprogrammed to monitor the operations of up to 100 modules and provide operator interface via such standard peripherals as a function keyboard/display unit, a color graphics CRT (19" or 25"), and a printer. Support is also provided for a dual floppy disc sub-system, for on-line mass data storage.

The basic unit (Model: DSM-1500-A3-A1) is configured to poll all the modules connected to it on a repetitive basis and maintain a "carbon copy" of their data base to facilitate the "down line" loading of a module that has been replaced for servicing. The modules attached to the DSM may be any combination of analog function modules (AFM's), digital control modules (DCM's), or digital function modules (DFM's) as long as the total number of modules does not exceed 100 and the data base size does not exceed the available random access memory (RAM).

Peripherals

The operator interface options allow the DSM to function as a stand-alone unit. There are two versions available and both consist of a function keyboard and a two line by sixteen character alphanumeric display. The first option is a locally mounted unit that becomes an integral part of the DSM. The other unit is a remote mounted assembly that is designed for table top mounting.



H. Robertshaw DCS-1000

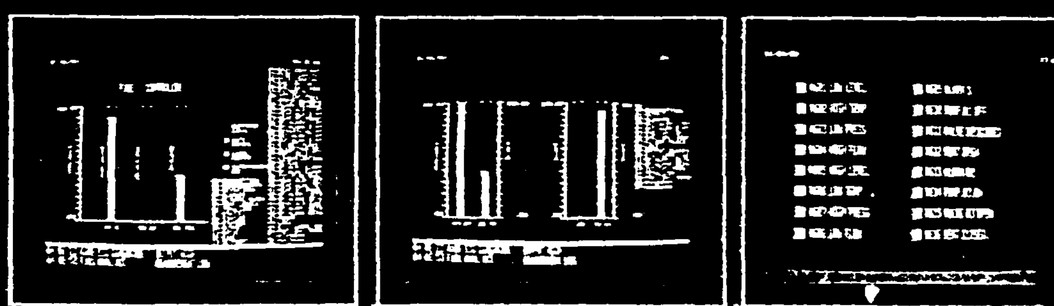
Printers

There are three different printer options available. The first option is a free-standing character printer with a print speed of 80 characters per second. The next version is a character printer with a print speed of 150 characters per second, bi-directional and is the standard unit. The other printer available is a line printer that prints at a rate of 125 lines per minute. This unit also has the capabilities of printing from the CRT screen.

Dual Floppy Disc Option

The dual floppy disc sub-system option provides the capabilities of storing historical operating data, a copy of the system data base, and the display shells for P & ID type CRT graphic displays. The interface is via a RS-232 channel which is part of the standard DSM. This option may be added to any DSM, either at the factory or in the field.

Samples of CRT displays for hardware modules



DCM AFM DFM Input

GROUP IV
Auxiliaries
A. Ratio Station
B. Manual Loader
C. Automatic/Manual Station
D. Indicator Stations
E. Totalizers

REMOTE TERMINALS
32 ANALOG IN
16 ANALOG OUT

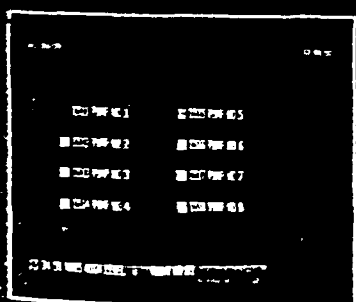
REMOTE TERMINALS
32 DIGITAL IN
32 DIGITAL OUT

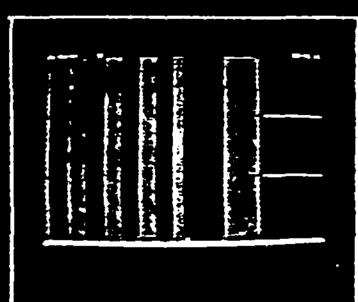
H. Robertshaw DCS-1000

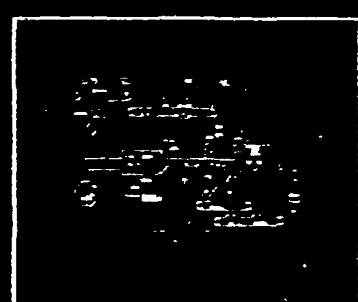
Various software options exist for applications oriented tasks such as mass flow correction, communications with a higher level computer, and virtual instrumentation packages.

The communications options available for the DSM are intended to support interfacing the DCS-1000 system to a higher level computer (HLC) in a hierarchical control network. The actual interface is implemented using a RS-232 channel which is a part of the standard DSM hardware package.

The communications option is available in two forms. The first is a binary oriented data transfer version which yields a low system overhead, but which requires more complex programming in the host computer. The other version is an ASCII oriented data transfer version which has a higher system overhead, but which uses simpler programming in the host computer. The ASCII version has message formats which are fortran compatible.


DFM Output


Trend


Graphics

MICON® I. MDC-200

THE CONTROL GENIUS

Heart of our System...the stand-alone Microprocessor Controller

MICON®, the ultimate answer for distributed control and maximum flexibility to configure pre-programmed control schemes. A completely self-contained controller with integral line power supply and an efficient operator interface.

MICON® makes possible functionally and physically distributed control and provides the standard capability to connect into a color CRT-based console. It gives process status information at "a glance" and offers the flexibility to select simple or advanced control strategies.

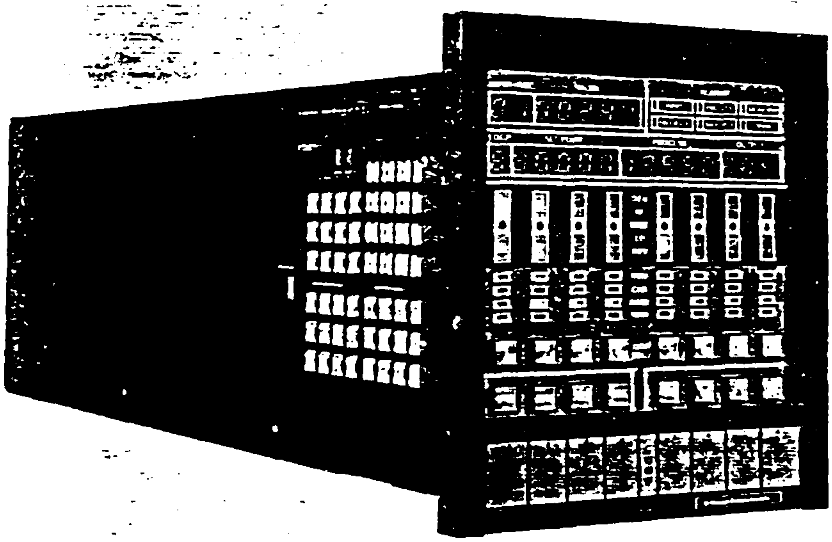
MICON®, a truly stand-alone microprocessor controller brings the power and flexibility of digital control to the process control instrumentation user without imposing liabilities found with other computer based systems.

Besides meeting all the needs for control of continuous processes, MICON® provides interlock, sequencing and batch-process capabilities.

MICON's® digital make-up, while giving unprecedented control flexibility, is not apparent to the user. Thus, MICON® may be operated by personnel with experience in classical analog instrumentation only.

MICON® accommodates the following process inputs-outputs;
- 15 Analog Inputs
- 8 Analog Outputs
- 16 Discrete (on-off) Inputs
- 8 Discrete (on-off) Outputs

MICON® can combine these inputs and outputs into eight completely separate or highly interconnected (linked) loops.



Controller nominal size 6"x6"x20"

MICON® P-200

A truly revolutionary advance in the state-of-the-art of process control.

AD-A125 160 DIRECT DIGITAL BOILER CONTROL SYSTEMS FOR THE NAVY SMALL BOILER EQUIPMENT(U) ULTRASYSTEMS INC IRVINE CA FEB 83 NCEL-CR-83.015 N62474-81-C-9388

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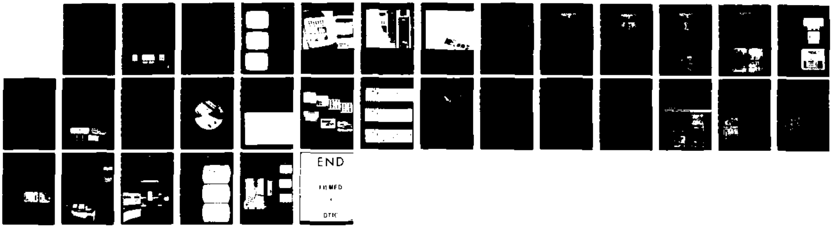
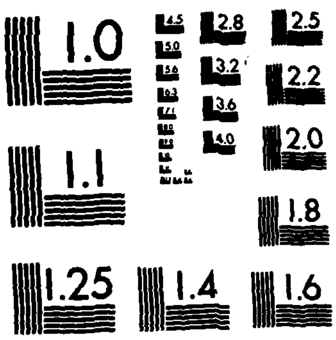




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

I. MDC-200

MICON®

THE CONTROL GENIUS

MICON® systems offer microprocessor control techniques, featuring significant advantages over conventional analog or computer-analog combination systems. The controller is designed to meet a wide variety of process requirements from simple 3-mode control to the most advanced functions. MICON® gives you micro-processor-based control in a system from a few loops to up to hundreds of loops, with maximum built-in reliability.

MICON® is highly cost effective. The function selection feature not only replaces separate computing devices in todays typical process plant, but also results in significant savings by providing the flexibility for future control strategy modification and optimization.

MICON® provides secure process optimization at the distributed control level and can be applied by any engineer or operator familiar with analog instrumentation. Design and manufacture of the controller assure maximum system security and reliability. Probability of failure is minimized through strict quality control and inspection. On-line diagnostics and backup station redundancy add to safety of operation.

MICON® P-200 is the result of several generations of microprocessor-based controllers. MICON® combines hardware and software techniques that have been developed by Process Systems, Inc. over the years. Both hardware and software have been thoroughly field-proven in a variety of control applications.

MICON's® unique deviation display, Digiscan®, along with alarm monitoring and accurate digital information provides an efficient operator interface for local, stand-alone operation.

Color CRT-based Operator Interface provides improved access to large amounts of process data. Instant recognition of off-normal conditions and quick corrective action is assured. Communication interface to connect the controllers to a central CRT-based station is a standard feature with MICON®.

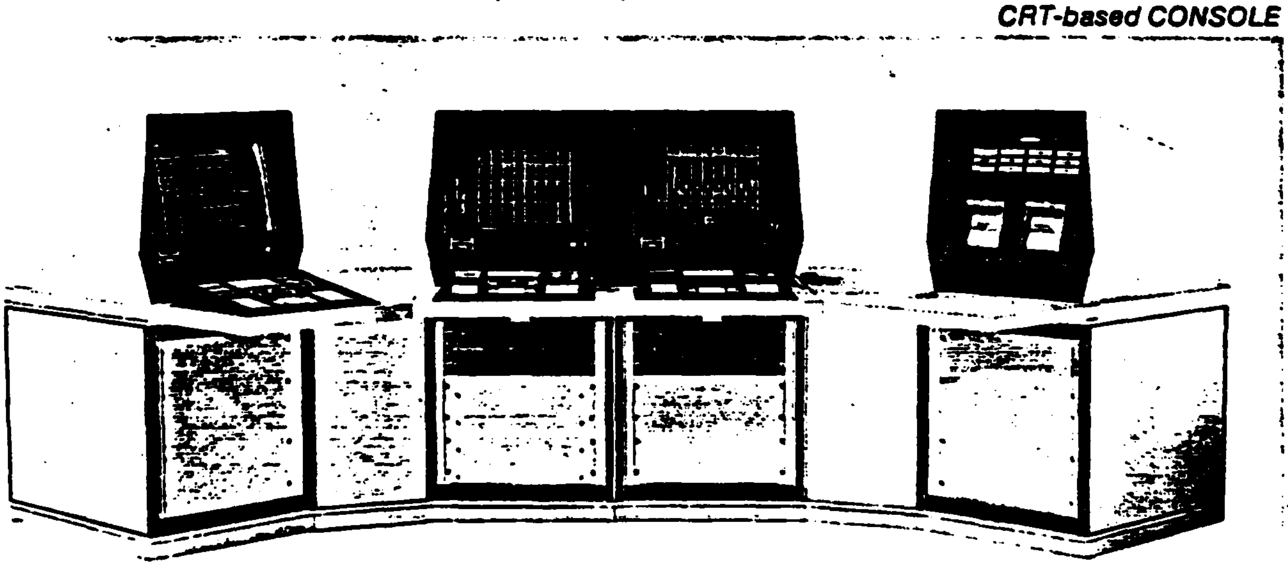
MICON® comes Pre-programmed. The controller has a library of over seventy functions which are available for each loop whether they are used initially or not. The user simply selects the desired functions and combines them into the control scheme of his choice. In addition to this function flexibility, an adaptive tuning feature provides optimum control response. Absolutely no computer programming knowledge is needed to set-up control schemes or to use MICON®.

Modular controller design provides total flexibility. Additional loops may be added in the field; loops may be reconfigured without new hardware. Build only as much system as you need, in the configuration you want. You can start with a simple system and later optimize your process. Sophisticated control functions are already built into the MICON®, whether they are used initially or not.

MICON® gets it all together... State-of-the-art control...Ultra reliability...Maximum control flexibility. Economy.

MICON® can make your process more efficient, often with the added benefits of energy savings, greater throughput, less process upsets and a better quality product.

CRT-based CONSOLE



MICON® I. MDC-200

Operator Interface

Any engineer or operator familiar with analog process control instrumentation can specify or operate a MICON® system.

EFFICIENT LOCAL OPERATOR INTERFACE

MICON® controllers are designed with a combined analog/digital operator interface.

Digiscan®, the unique LED bargraph deviation display allows the operator to quickly scan all control loops and spot deviation from the set point. This scanline technique was originally developed and used to enhance error display in analog controllers. Digiscan combines this feature with the microprocessor in MICON® to display off-limit conditions equally well in both temperature and flow where small deviations are critical, or level conditions where large deviations may be acceptable. Each loop may be adjusted individually depending on the sensitivity required.

Detailed loop information is selected by depressing a single pushbutton. Input, alarm and ratio parameters are displayed. Mode selection, set-point changes and output manipulation are done directly from the front panel.

Overall, MICON's® elaborate front panel emphasizes the controllers stand-alone capability combined with an interface familiar to process instrument personnel.

CRT-BASED CENTRAL OPERATOR INTERFACE

In systems containing many control loops, a CRT-based Operating Center is normally used in addition to the controller interface. This display interface is a combination of analog-like bar graphs, alpha numeric descriptions and graphic displays.

Color CRT's allow the operator to rapidly analyze and correct off-normal process conditions.

KEYBOARD AND CRT DISPLAY INTERFACE

The operator will normally rely on the Overview, Alarm and MICON® displays because they enable him to monitor the entire plant and make changes by push-button to any loop in the system. For best plant operations, an operator works with three operator stations, each equipped with a color CRT display and a keyboard, thus providing three simultaneous displays. Since each color CRT has all displays available, centralized control supervision can continue if one or even two CRTs become inoperable.

To complete the operator's view of the process and to fulfill all engineering requirements, other displays, such as Profile Trend, MICON® Detail, etc. are available at every CRT.

ANNUNCIATORS AND LIGHTED PUSHBUTTONS

In addition to the controllers and the color CRT alarm annunciators, separate audible/visible consolized alarm units may be added.

TREND RECORDING

Hard wired analog recorders may be included in the system to provide long-term hard copy profile trending. Recording is either direct from analog inputs or by MICON's® selected value recording feature.

RANDOM ACCESS PROJECTOR

This option provides a convenient, low-cost means of displaying mechanical flowsheets, start-up/shut-down instructions, etc.

PRINTER

An optional printer is available to automatically log critical alarms and to provide permanent records of plant operation. Data is preserved for reporting, process analysis and other uses.

VIDEO COPIER

Option hard copy recorder produces a black and white paper printout of any display, exactly as it appears on CRT screen.

Standard CRT Displays

Each color CRT monitor is pre-programmed to provide a variety of displays. All these displays have been human engineered to best convey process control information to the operator.

CONTROL DISPLAYS

Control displays are used in the normal operation of the MICON® MDC-200 system and consists of:

- MICON® Overview
- Group Overview
- MICON® P-200
- Group
- P-200 Loop
- P-200 Input
- Profile Trend
- Annunciator
- Alarm Summary
- Function Value

HOUSEKEEPING DISPLAYS

Housekeeping displays are used to define the MDC-200 system functions and to configure the MICON® controllers.

Housekeeping Displays include:

- CRT Display Configuration
- MICON® P-200 Configuration

INDEXING AND TRACING DISPLAYS

The Indexing display function is provided to enhance operator speed in identifying control loops, sequences, etc., and to aid the engineer in defining system tags.

The following index displays are included:

- Tag Search
- Sequence List
- Sequence Detail

GRAPHIC DISPLAYS

The Graphic Display feature gives the user the capability to create his own displays in any format to provide whatever information is needed.

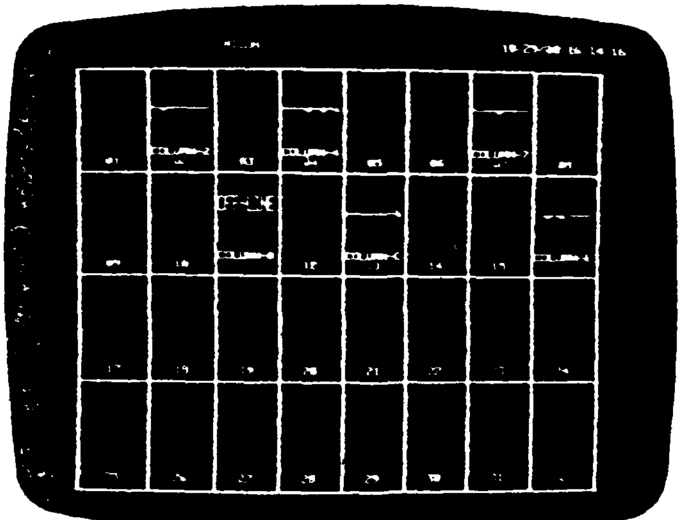
CRT KEYBOARD

A single keyboard with dedicated function pushbuttons for each CRT monitor is provided. These keyboards allow any person, either operator or engineer, with a working knowledge of the process and experience in classical instrumentation, to be quickly trained to operate the system.

I. MDC-200

MICON

THE CONTROL GENIUS

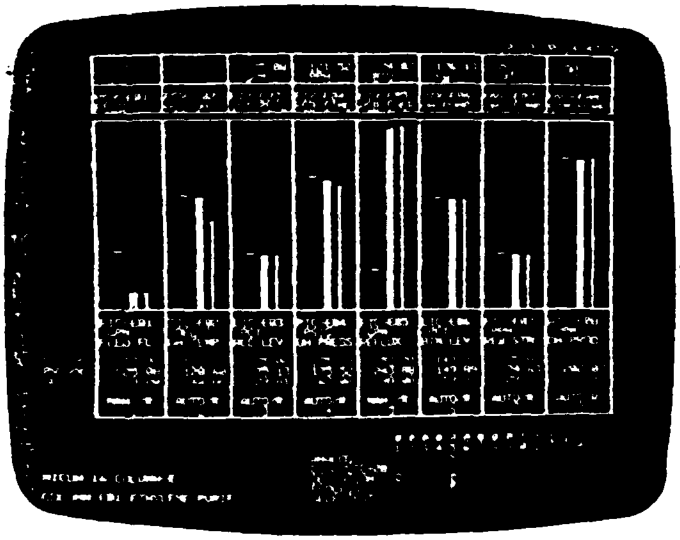


OVERVIEW DISPLAY

The Overview display provides the operator with a total plant display in a "deviation from target" format. As many as 256 control loops (32 MICONs®) can be displayed at one time. Each square presents a MICON® and the bargraphs indicate deviation of the eight MICON® loops. The topmost screen area shows system data and system alarm condition.

At a glance, an operator can spot problems and immediately identify any loop in alarm.

The display is called up by pushing the "Overview" button on the keyboard.



MICON® DISPLAY

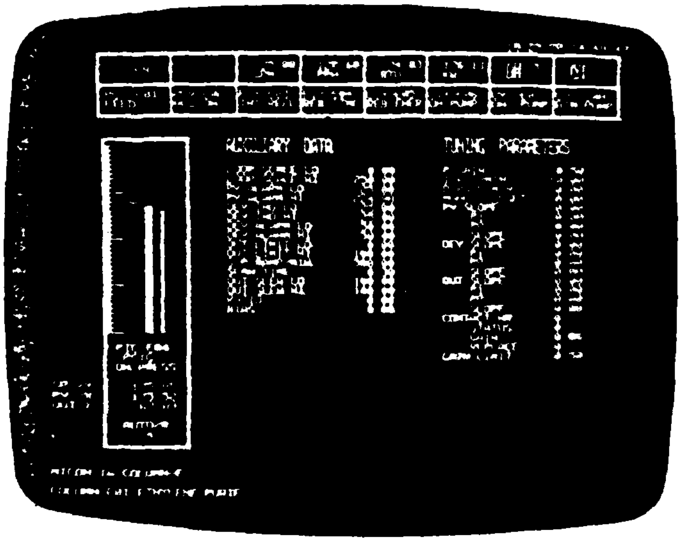
The MICON® display is designed to provide essentially the same information as the MICON® itself, but with the enhancement of the color CRT. The display shows eight control loops, displaying all the pertinent data for each loop, including PV's, set-points and outputs (if a control loop).

Eight miscellaneous displays (above loop bargraphs) are provided which can be configured to indicate signal values (inputs, functions) or discrete (on-off) statuses.

The top display area contains system alarm and information. The bottom display section provides the mnemonic description of the MICON®, operating status and a summary of MICON® alarms.

Loop parameters and control modes can be altered by the operator with display. The display can also be used to change discrete (on-off) outputs.

The use of the 32 dedicated "MICON®" buttons and the eight loop or discrete select buttons provide 2-button access to any of the control loops or discretes.



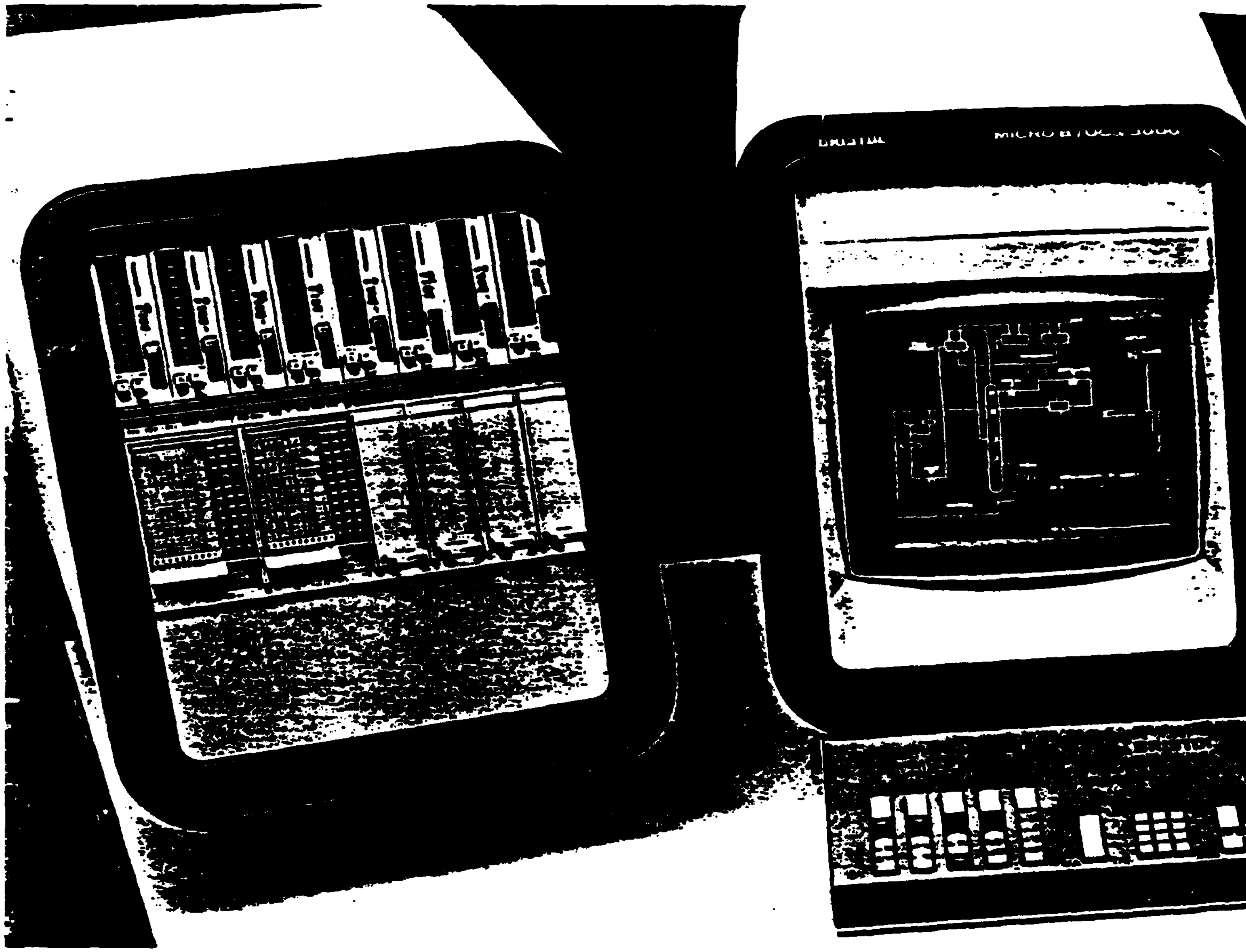
LOOP DISPLAY

From a MICON® display, the operator can call up a loop detail by depressing the "LOOP" button and entering the loop number. Values associated with the selected loop can be monitored and manipulated from this display.

Auxiliary Operating Data and Tuning Parameters are displayed to allow verification of all loop operation details. Dedicated buttons to manipulate this data are located on a separate section of the keyboard and are "pass word" protected.

The top section display area repeats the MICON® misc. display, system alarm and information.

J. Bristol Babcock UCS–3000



Bristol Babcock UCS 3000. Fingertip control.

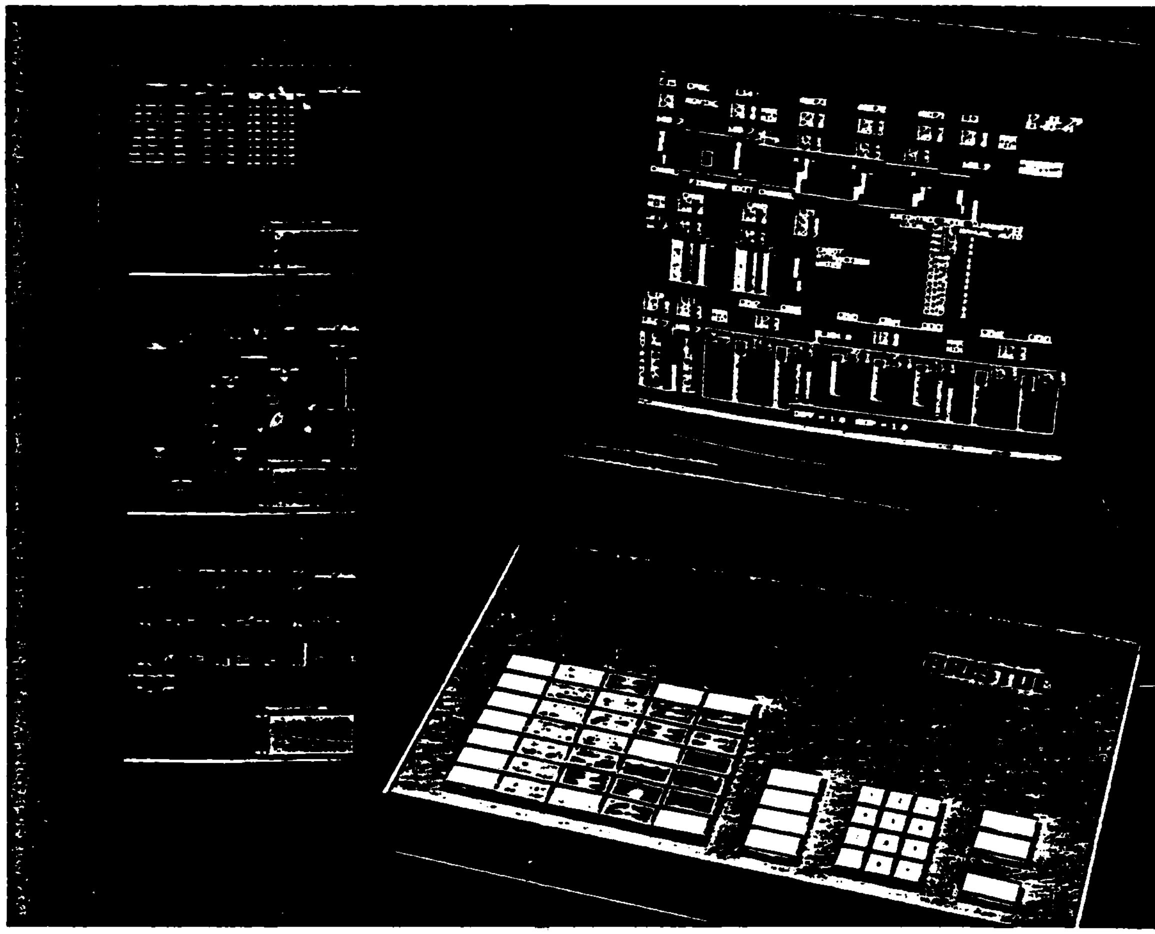
The first microcomputer-based control system for the process control industry. The UCS 3000 can monitor and control complex process operations with ease and accuracy. No programming required!

The Bristol Babcock UCS 3000 Process Controller is one of the most significant advances in process control. It offers the power, scope and versatility of a computer.

It has been designed for control engineers with the capability to perform advanced control schemes. It provides a new level of process monitoring and control features for implementation by control and process engineers. The UCS 3000 has unsurpassed flexibility. The system can be easily expanded with standard modular hardware and Bristol Babcock's unique, pre-programmed software modules to meet any application.

When originally installed for a specific purpose, it can be easily adapted to control an entirely different process with equal efficiency—exactly as though it has been custom designed for both. The capability of communicating with a supervisory computer control is a standard feature of every UCS 3000. It may not be required in the initial configuration, but it provides unmeasurable flexibility in future planning.

J. Bristol Babcock UCS–3000



Operator Interface.

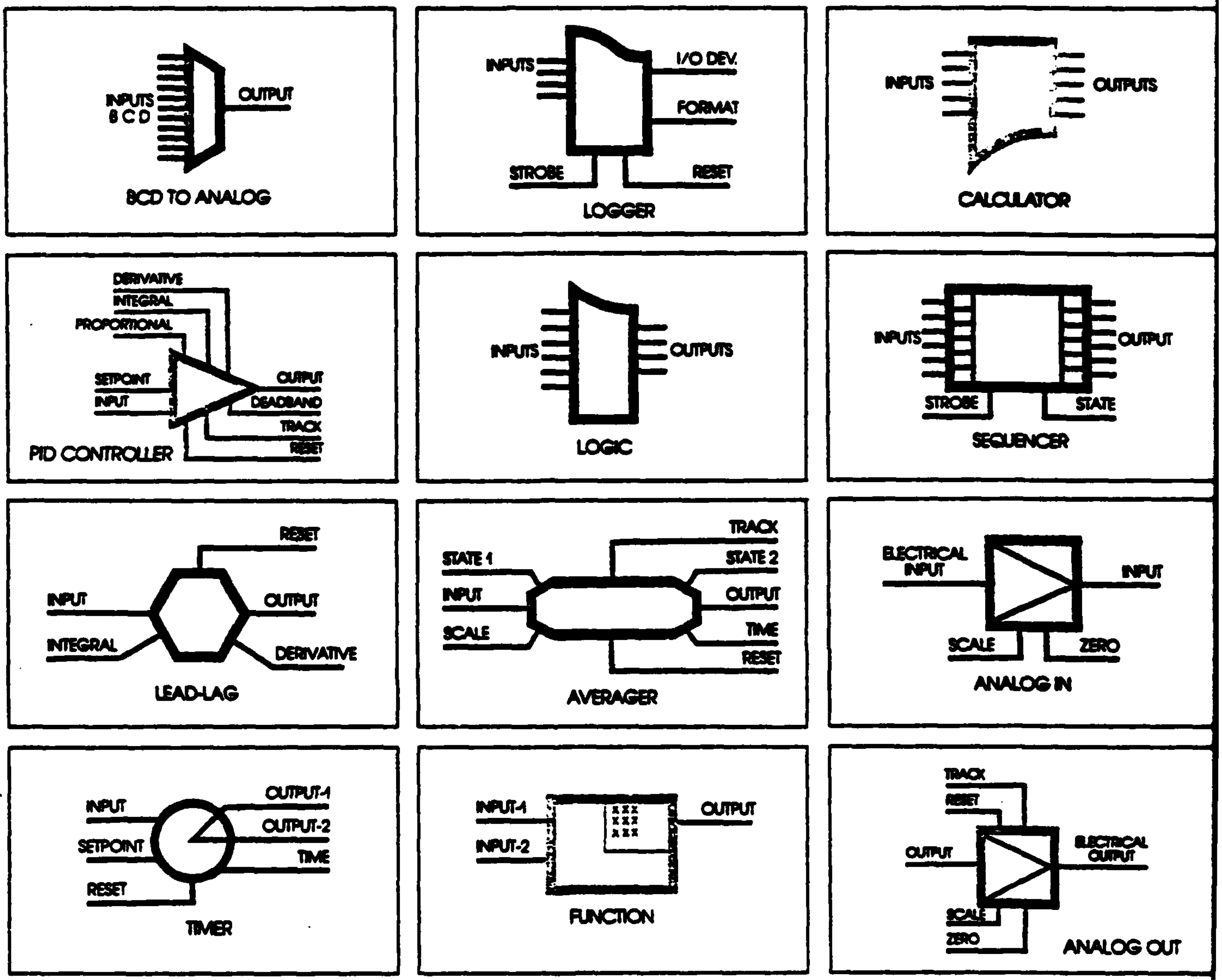
Complete flexibility and ease of operation are the key features of the UCS 3000.

The Colorgraphic CRT provides a direct interface to display real time data, trends and alarms. Control schemes, graphics and plant mimics can also be displayed. Special symbols provide a means for drawing process vessels, valves, process piping and transmitters. The process data is schematically represented in a meaningful format that enables the process operator to make timely decisions relating to the process. Eight colors are available to identify the relationship between bar graphs, trend recordings, point plots and to indicate alarm or abnormal conditions.

The Colorgraphic CRT is microprocessor-based so it does not overload the UCS 3000 Process Controller. Using the keyboard, properly authorized personnel can call up displays, inspect signals, change values and perform a variety of logical actions.

The keyboard is comprised of 35 user configurable function keys that are relegendable by the customer; seven additional function keys are dedicated to specific fixed functions, and to a 12-key numeric block. Together, they enable the operator to perform the following functions: Modification of analog and logical variables, command verification before implementation, operator sign-on/sign-off and cancellation of keyboard sequences.

J. Bristol Babcock UCS-3000



Pre-Programmed modules eliminate programming.

This unique controller communicates with the control engineer in the language he knows. Gallons, tons, temperatures, pH or any other process variable. The UCS 3000 employs a series of pre-programmed modules that emulate the hardware functions of a control system. Thus, the control engineer can still deal directly with standard instrument technology. These modules functionally perform operations identical to such hardware components as timers, counters, integrators, programmable controllers, PID controllers function generators and programmable calculators. To produce a control scheme, the control engineer merel creates a block diagram utilizing th modules and fills in a form for each module specified.

He specifies, in English, such items a signal names, initial setpoints, engineering units. For flexibility, modules may be added or deleted from the control scheme on-line, whenever a different situation is required. Collectively, the control engineer has been provided with an extremely compre hensive and easily applied control capability at his fingertips.

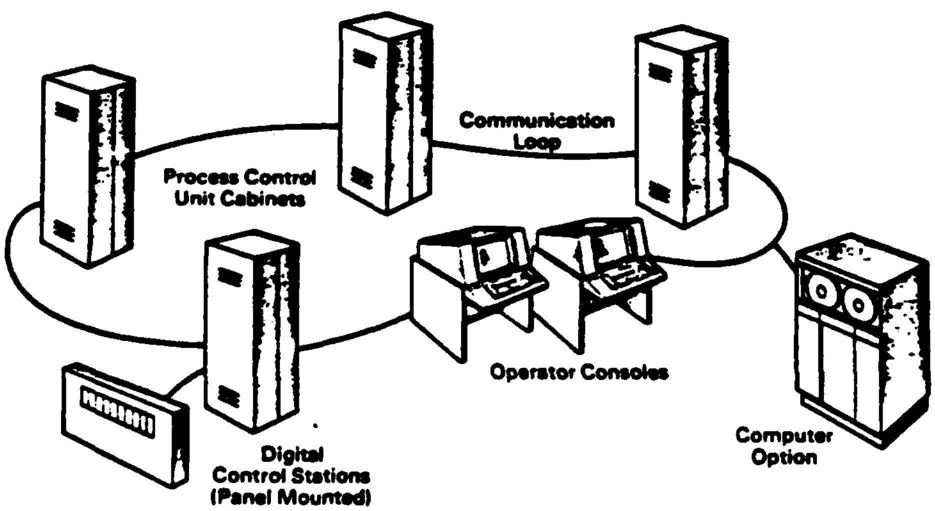
K. Bailey

System overview

Network 90 offers complete flexibility in production line application for both small and large plant operations. The ready availability of Controller, Logic, Input/Output and Interface modules allow you to expand Network 90 from a basic stand-alone capability, to a fully integrated plantwide process management and control system — or anything in-between.

A few of the outstanding features of Network 90 include:

- Modulating PID control and sequential logic control integrated into one comprehensive system.
- Microprocessor and advanced digital technology for high performance, capability and reliability.
- Complete flexibility in production line application for both small and large plant operations.
- Distributed multiplexing throughout the network and high security data communication.
- Batch operation capability.
- Conventional and CRT based operator interfaces.
- Computer interface capability.
- Both functional and geographical distributed control and operator interface.
- Communication between all modules and devices on the Plant Communication Loop.
- Data transmission on either a request/respond (polling) basis or exception transmission for fast response.
- Standard modular design.
- User configurability.



System architecture

A plantwide Network 90 configuration consists of a number of Process Control Units (PCU), and other devices which provide operator interface and optional computer interface. All elements of the system are interconnected through a Plant Communication Loop to meet the requirements of process control and data acquisition. The Process Control Unit, however, is an independent configuration which interfaces directly to process signals. The PCU is the cornerstone of the Network 90 system; it is where the control and data acquisition take place.

(Remember that Network 90 is a complete product line which allows the user to select, order and configure the system for his own application. Configurations of the Network 90 may include both CRT and local operator interface, as well as integration to a centralized computer.)

The key elements for building an integrated control system with Network 90 are presented in the illustration.

K. Bailey

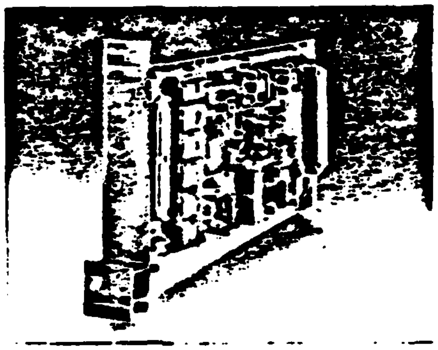
network 90

Controller module

Incorporating the latest digital technology, the microprocessor-based Network 90 Controller Module (COM) is used for closed loop control. Each Controller Module can be configured for single loop or multiloop application, and features a high level of security.

Each Controller Module can be configured for any mix of function types within the limits of the memory and I/O capability. Typically, a Controller Module with an Expander Board can be configured for two PID control loops with Digital Control Station display plus five arithmetic, signal processing or status, or binary logic functions.

The Controller Module accepts up to four analog and three digital inputs, and provides up to two analog and four digital outputs for control. The module is self-checking, with I/O status monitoring and I/O quality determination. In the event of a module failure, the output returns to a state which is pre-selected by the user.



The Network 90 basic Controller Module offers two-way communication to other modules and remote Process Control Units via the Module Bus and Plant Communication Loop. Process inputs and outputs are directed to the Controller Module through the associated Termination Unit.

A few of the outstanding features of the Controller Module include:

- A comprehensive library of function block types.
- Reliable microprocessor technology with full diagnostic routines.
- Accurate, drift-free digital control.
- Communication with other modules over the Module Bus and Plant Communication Loop.
- Non-volatile memory.
- Exception reporting.
- Single slot mounting in standard Module Mounting Unit.
- No cabinet wiring, cable-connections to I/O devices.
- Both analog and sequential logic functions available in a single module.
- Single loop integrity.

Controller functional library

Arithmetic	SUM - 2 INPUTS SUM - 4 INPUTS MULTIPLY DIVIDE
Controller	PID CONTROL / ERROR IN PID CONTROL / PV & SP IN
Signal Processing	LEAD / LAG TRANSFER HIGH SELECT LOW SELECT HIGH / LOW LIMITER FUNCTION GENERATOR MANUAL SET CONSTANT MANUAL SET SWITCH SQUARE ROOT ADAPT
Signal	HIGH / LOW COMPARE TEST QUALITY REAL TEST QUALITY BOOLEAN TRIP BLOCK
Binary Logic	AND - 2 INPUTS AND - 4 INPUTS OR - 2 INPUTS OR - 4 INPUTS NOT MEMORY TIME DELAY QUALIFIED OR - 8 INPUTS
Process I/O	ANALOG INPUT ANALOG OUTPUT DIGITAL INPUT DIGITAL OUTPUT PULSE POSITIONER
Station	STANDARD STATION RATIO STATION CASCADE STATION
Module Bus I/O	REAL INPUT / LOCAL REAL INPUT / REMOTE REAL OUTPUT / LOCAL REAL EXCEPTION / ALARM REPORT BOOLEAN INPUT / LOCAL BOOLEAN INPUT / REMOTE BOOLEAN EXCEPTION / ALARM REPORT
Executive Function	MODULE MODE INTERLOCK (TUNABLE PARAMETER) EXCEPTION REPORT DEFINITION
Control Station	PID AND STANDARD STATION

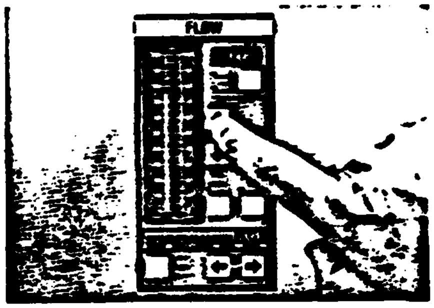
K. Bailey

Digital control station

The Digital Control Station is a completely passive, conventional operator interface that incorporates advanced digital display and distributed control technology in both manual and automatic features. It is a panel-mounted monitoring and control station which is cable connected to the Network 90 Controller Module. The Digital Control Station provides complete local control capability in a single station.

As a local operator interface, the station provides displays, alarm indication, and manual/auto capability for discrete station control of the Controller Module and associated drive mechanisms. Optional capability includes station control from a remote supervisory control center, and an integral 4-20 mA bypass to permit removal of the Controller Module when required.

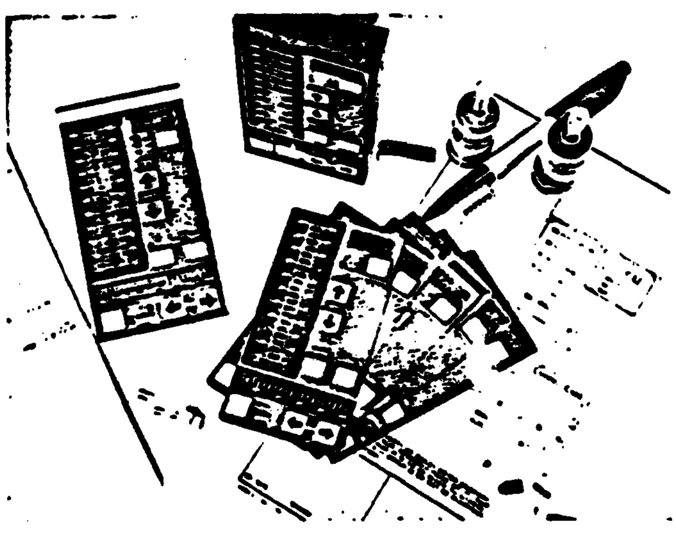
The station includes a four digit numeric display with sign and floating decimal point, providing maximum panel density for highly accurate display of set point, process variable, and control output. The station offers a wide range of capabilities, including adjustments for set point, cascade/ratio control, and controller output. Alarm indications are provided for both high and



low process variable conditions. Manual control of the Controller Module output (4-20 mA or 1-5 V dc) is two speed (approx. 50 or 5 seconds for full range).

Interfacing arrangements for the Digital Control Station are easily accomplished using plug-in cable connections. A single cable accommodates up to four stations in daisy-chain arrangement.

The Digital Control Station is designed with full attention to human engineering factors for complete operator convenience. The operator panel of the station is simple and concise, to permit accurate, efficient operation by personnel with minimal training.



A few of the outstanding features of the Digital Control Station include:

- Complete operational control capability in one station.
- Highly accurate numeric display and LED bargraphs for pattern recognition.
- Displays: Process Variable, Set Point and Control Output or drive position.
- Adjustment for set point, control output, bias and ratio. Parallax is eliminated.
- Alarms: Indication of high and low process variable.
- Manual Control: Two speed — 50 sec. or 5 sec. for full range travel.
- Transfer Functions: Manual/Auto, Computer/Local and Ratio, Bias and Cascade set point selection.
- No cabinet wiring required — plug-in cable connection.
- Standard 72 × 144 mm DIN panel mounting.
- Integrally mounted 4-20 mA controller bypass for additional system security.
- Isolated contacts available for direct manual control of electric or pulse operated pneumatic drives.

K. Bailey

network 90

Operator interface unit

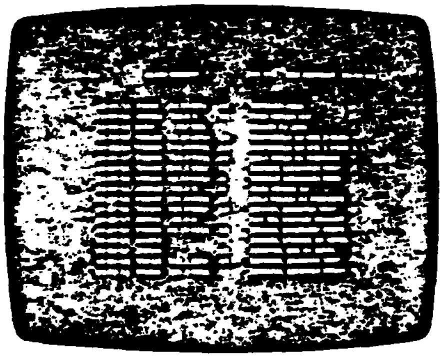
The Operator Interface Unit (OIU) is human-engineered for effective centralized display and easy operator control. It provides the high level operator interface for Network 90 systems. The OIU consists of one or more CRT-based consoles, each with functional keyboard mass storage device, and console driver electronics. In addition, an optional printer for hard copy of alarm logging and display is available.

In operation, the unit fulfills the system information display and control requirements with improved operator interface capability. The OIU Console includes a CRT keyboard and dedicated pushbutton hardware for process overview, alarm indicating, loop control, trending, tuning and configuration functions at a central location. The station provides hierarchical displays of process information in a three level system (Area Overview, Group and Loop Details).

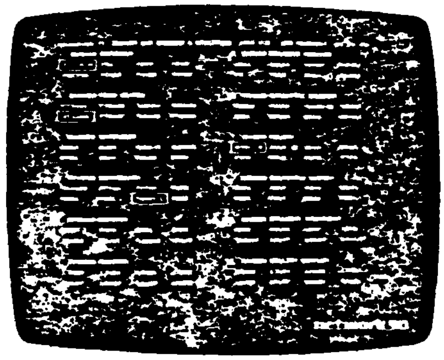
The OIU can display up to 511 blocks of process data information, each identified with a unique "tag" assigned by the user. Up to 60 Group Displays, each consisting of eight typical data blocks are provided. The five Area Displays each provide an overview of twelve of the 60 Groups.

The details of any information block can be immediately displayed by the operator. Displays are organized by process function, providing easy recognition and supervision. Single step access to critical displays facilitates quick operator response to process upsets and alarms.

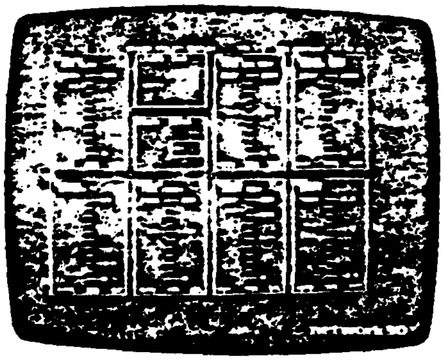
The OIU furnishes complete monitoring, supervisory, recording and display capability at centralized or distributed locations, along with engineering functions. Plant Communication Loop interface is maintained through the Processor Interface Module and Loop Interface Module. Standard mounting and styling are used for all interface components to reduce installation requirements.



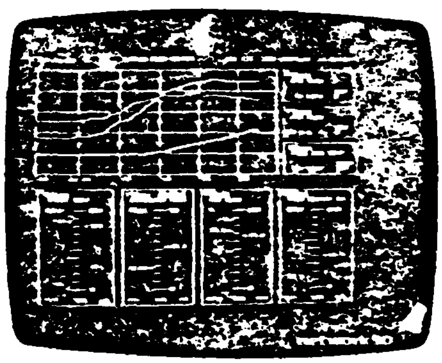
Alarm Summary Display



Area Display



Group Display



Trend Display

L. Honeywell TDC-2000

BASIC Operator Station

The BASIC Operator Station is the primary operator interface of the TDC 2000 BASIC system. It enables the operator to monitor and/or manipulate up to 1000 points from a single location, providing centralized operation in a distributed system.

The BASIC Operator Station (Figure 7) consists of a video monitor, a keyboard, one (optionally two) diskette drives, a 14-card position card file, and a power supply mounted in a desk-type console. The video monitor uses a 19-inch CRT with four-color capability and presents visual displays of process operation and system functioning.

The keyboard (Figure 8) allows the operator to select displays, to enter or alter the data base of Data Hiway connected system modules, and to manipulate control loop operation. The diskette drive is a modular unit that drives a flexible magnetic diskette containing up to 468K of 16 bit data words. These diskettes are used to enter programs into the BASIC Operator Station and to define displays. The card file, which is microprocessor based, includes firmware control programs that enable the BASIC Operator Station to handle keyboard entries, to read data from devices in the Data Hiway, and to assemble this data in preconfigured formats for display on the CRT.

Displays

The BASIC Operator Station includes a comprehensive set of sophisticated data configuration and operating displays. Data configuration displays facilitate the entry of data base information such as user-defined point tag names, group titles, process library descriptors, group and alarm group (point) assignments, and alarm group size. Operating displays are used for monitoring and manipulating a process operation.

Operating displays allow an operator to recognize and react to significant process conditions quickly and positively. These displays are based on the operation-by-exception technique, which emphasizes only those items that deviate from desirable or acceptable conditions.

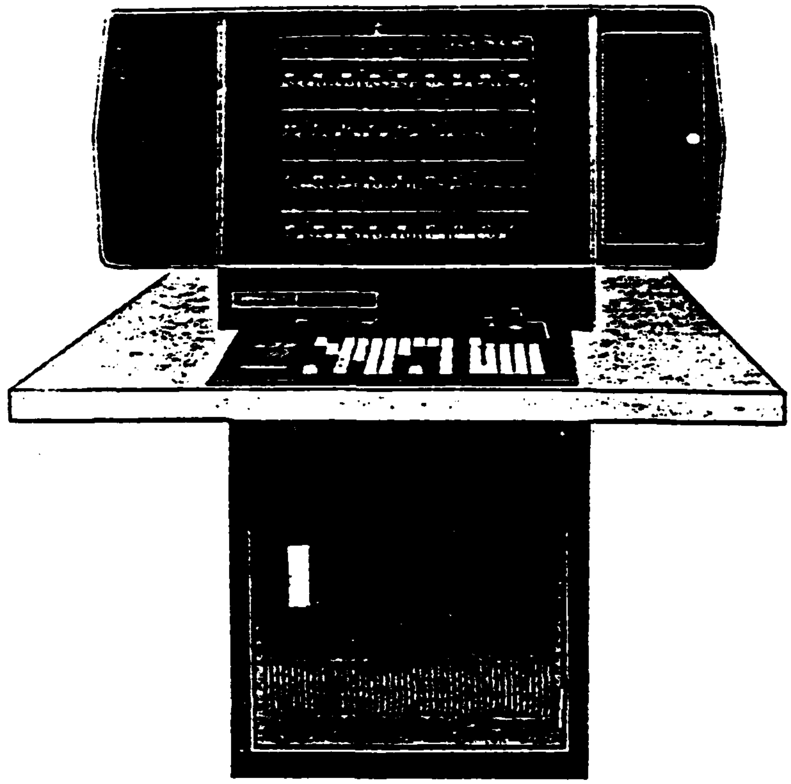


Figure 7 - BASIC Operator Station

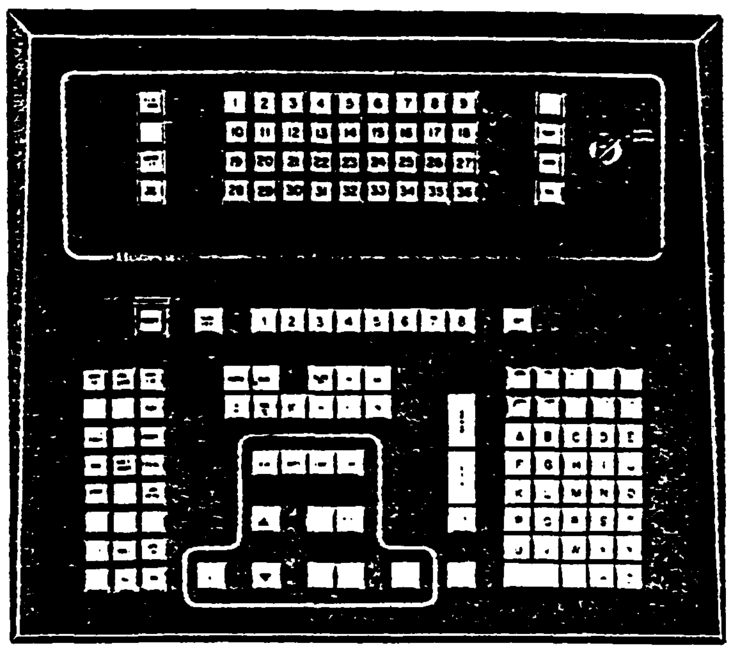


Figure 8 - BASIC Operator Station Keyboard

L. Honeywell TDC-2000

Overview Display

In the Overview display, (shown in Figure 9.) process variables for 288 control loops are shown in 36 groups of 8 loops per group. A deviation is shown by a vertical line above or below a horizontal bar that represents the set point. Small horizontal lines above and below the setpoint bar represent limits preset by the user. Any deviation is easily recognized and is identified with its group, whose name appears in green immediately below the graphic representation. If the deviation exceeds the alarm limit, the vertical line is replaced by a red A, and the group name changes from green to red.

Group Display

The Group display provides a separate display for each of 150 groups, including the 36 shown in the Overview display. Analog and digital points and counter inputs can be combined in a single Group display. The analog point is represented graphically by PV and output variable-length indicators and an SP magnitude marker. Scaling marks at the left of the display, given in percent of full scale, quantize the length indications. PV, SP, and output magnitudes and Ratio and Bias values are shown numerically and may be modified from the Group display via the keyboard. Also, mode can be changed from this display. The digital point is represented graphically by a pair of simulated pilot lamps and by configurable alphanumeric state descriptors.

Detail Display

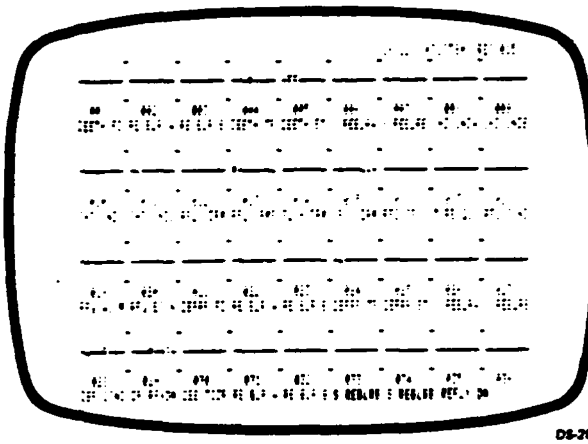
The Detail display provides a separate display for each of up to 1000 points. The graphic representations of analog and digital points are similar to those of the Group display, but the Detail displays include alphanumeric representations of all variables and parameters for a single loop. All control parameters for a point (some of which are accessible only by keylock) can be modified from the Detail display via the keyboard.

Other Operating Displays

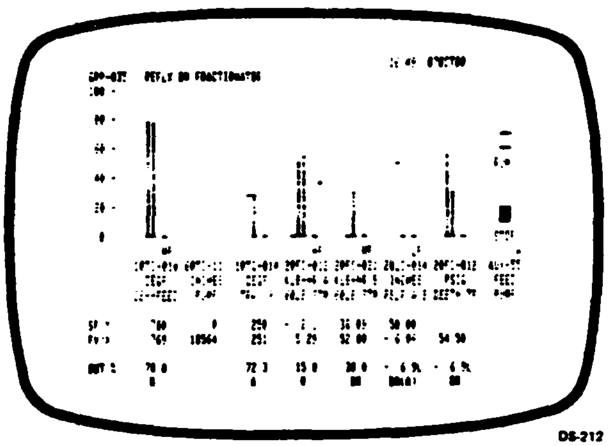
Other operating displays included in the BASIC Operator Station provide comprehensive control and monitoring capabilities. Some examples of these capabilities are:

- Trending
  - A trend memory (optional on the Basic Controller and standard on the Extended Controller) allows controller inputs to be displayed graphically on the CRT. Also, hard copy can be provided on optional pen recorders or printer

Overview Display



Group Display



Detail Display

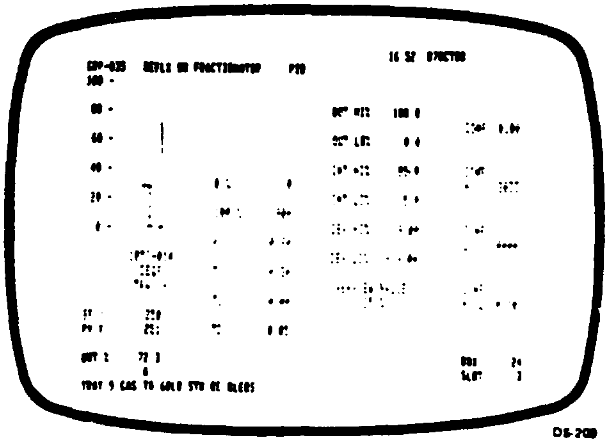


Figure 9 - Overview, Group, and Detail Displays

L. Honeywell TDC-2000

- Hourly Averages
  - The hourly averages for each input of eight points in a group are displayed numerically. Displayed data represents the previous ten hours of operation.
- Alarms
  - The Alarm Summary Display relates, for each point in alarm, the time of occurrence, tag name, type of alarm, descriptors, operating group number, and the total alarm count. The most recent alarm appears at the top of the display.
  - The Alarm Group display groups related points for alarming and alarm display.
- System Diagnostics and Reporting
  - The Hiway Status display shows the status of each box (including primary and reserve controllers) on the Data Hiway. The status information, presented in Abbreviated English for quick fault identification, is derived from diagnostic codes generated by the self diagnostic routines performed in each box.
  - The Box Diagnostic Display includes a separate display, with expanded status information, for each box on the Data Hiway.

Preferred Operating Center

It is recommended that three BASIC Operator Stations, along with a printer diskette, and recording devices, are used in a single operating console as shown in Figure 10. Each BASIC Operator Station is configured with the same data base from the same diskette and can perform identical functions, but can be used advantageously in dedicated functions.

One station would allow continuous monitoring of all critical loops in the Overview display, and a printer at this station would be used for trending, logging, and documentation of operating changes. Another station would allow continuous monitoring of the Alarm Summary display, giving immediate notifications of alarm situations. A printer at this station would log alarm events for record keeping. The third station would be used for monitoring and manipulating individual loops via the Group display, and for viewing results of manipulation on the Trend display. Trend recorders would be used at this station.

The use of three stations has an important security advantage. Because all three are totally independent and have the same functional capability, any one can assume the functions of any other in the event of equipment failure.

TDC 2000 BASIC System Operation

For discussion purposes, system operation can be divided into four parts: configuration, data entry, normal operation, process upset, and system monitoring. Except for system configuration, which is performed separately at system start-up, these operations can occur concurrently or in any order.

Configuration Data Entry

Configuration data entry is the process of loading configuration data, which includes all information required to define system functioning, into the data base of the BASIC Operator Station and each Data Hiway device. Prior to entry, configuration data is tabulated on forms (supplied by Honeywell) that organize the data to facilitate entry. A configuration program, which includes displays that correspond to the configuration forms, is loaded into the BASIC Operator Station. Data entry is accomplished by operating (unlocked) keys on the keyboard to transfer the data on the forms into the appropriate locations on the displays. The data is transferred automatically into memory. The data in memory may be "Saved" on a diskette, using the off-line operating program.

Normal Operation

Normal operation consists of process monitoring and occasional loop adjustments. Process monitoring primarily involves the Overview display, the Group display, and the Alarm Summary display, which are usually shown on three separate BASIC Operator Stations. The Overview display shows 288 points in 36 groups of 8 points per group in a rectangular array. The deviation for each point is represented by a vertical line whose length indicates the magnitude of the deviation. Because the deviations are emphasized, the operator can scan all 288 points very quickly, and can easily identify those points that warrant attention.

When additional information on or adjustment of a point is indicated, its related group is called up on the Group display. This display quantizes the status of up to 8 loops graphically and numerically, and enables the operator to make adjustments to set point, output, control mode, and ratio and bias. Any of 150 groups, including the 36 included in the Overview display, can be called up on the Group display for viewing and

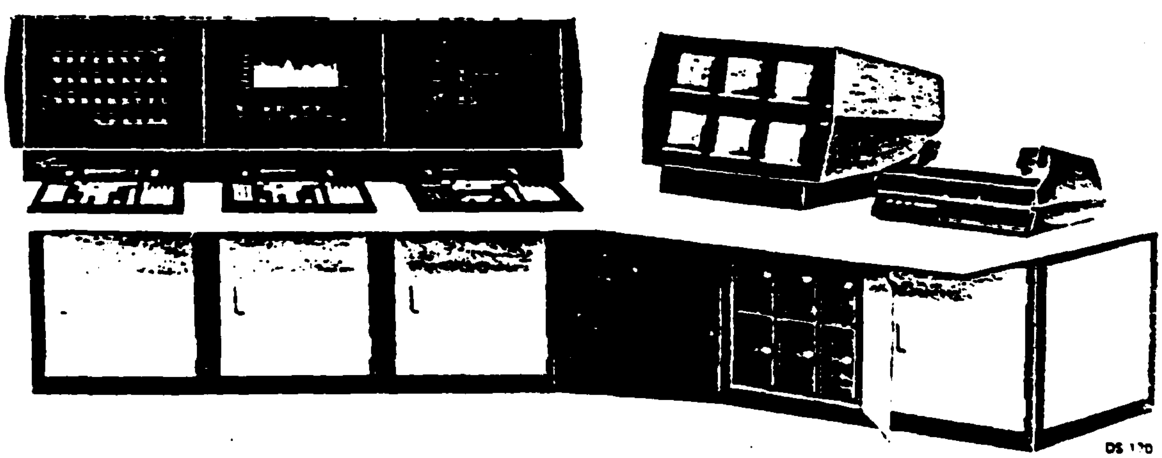


Figure 10 - Preferred Operating Center

L. Honeywell TDC-2000

adjustment. If it is desired to view a single point in more detail, any of a possible 1000 points may be called up in the Detail display. This display is a graphic representation of loop behavior and alphanumeric representations of all loop parameters. This display allows the operator to change the same items as on the Group display, plus the Overview Index. The BASIC Operator Station is keylocked in normal operation, which prevents alteration of other parameters.

At any time during normal operation, the operator may initiate for any of the 150 groups displayed:

- Real-Time trend recording of the eight process variables associated with that group, on conventional 4-inch, 3-pen recorders.
- Graphical print-out of historical trend data for up to eight process variables associated with that group.
- Tabular print-out of hourly historical data for up to eight analog process variables of that group for the last 10 to 30 hours.
- A print-out of the alphanumeric portion of any display on the screen.

The operator may also call up Trend displays for one or two points in a group, or may call up the Hourly Averages displays for up to eight points in a group.

The Alarm Summary display is a chronological listing of points in alarm. In normal operation, alarms (and listings in the display) are infrequent or absent. If a point does go into alarm, it is shown immediately on the Alarm Summary display and an audible alarm is activated. Thus, the operator need not be "glued" to the Overview display. He can perform other tasks, confident that significant situations will be brought to his attention immediately. The Alarm Summary display also indirectly allows the operator to monitor more points (600 points can be configured for alarming, while 288 points are available on the Overview display).

Process Upset Operation

Notification of a transition from normal to process upset operation is automatic: The BASIC Operator Station configured for alarm scanning continuously interrogates all Data Hiway devices and announces any alarm reported as follows:

- An audible alarm at the operating console is sounded.
- The Alarm Summary display will show the time of occurence (hours, minutes, seconds), the tag name (point), four descriptor words, and the operating group identification and the total number of points in alarm.
- The vertical line on the Overview display will be replaced by a red 'A', and the group number will turn red.
- On the Basic Operator Station configured for alarm scanning, the group key corresponding to the affected alarm group will flash.

Upon notification of an alarm, the operator first identifies the point or points in alarm, then calls up the appropriate display for corrective action. If the alarm is shown on the Overview display, he calls up the group whose number is shown in red. If the alarm is not shown on the Overview display, the operator calls up the appropriate Detail display, using the tag name shown on the Alarm Summary display. In either case, the operator uses the display and the keyboard to restore normal operation. As each point is restored to normal, the appropriate alarm notifications are removed from the Alarm Summary display and other displays. This process is continued until all alarms are cleared and normal operation resumes.

System Monitoring

System monitoring enables the operator, seated at the operator console, to observe the operational status of each Data Hiway device. Each device continuously performs self diagnostics, and reports its status to the BASIC Operator Station, which scans all devices every five seconds. This diagnostic/scan is performed in the "background" mode, and does not involve any operator action.

In the event of an equipment malfunction, the operator is immediately notified via an audible alarm and a flashing Hiway Status key on the keyboard. To determine which device failed and how it failed, he depresses the Hiway Stat key to call up the Hiway Status display. This display shows the number, type, and status of all (up to 63) devices simultaneously, with malfunctioning units shown with a blinking red code. Status information is shown in abbreviated English for quick fault identification.

If additional information is required to further isolate a malfunction, the Box Diagnostic display can be called up from the Data Hiway display. This display, which includes a separate display for each device on the Data Hiway, details a device's status in error codes and in English descriptions corresponding to the error codes. In many cases, the information given in the Box Diagnostic display will identify a specific failing printed circuit card.

The system monitoring capability built into the TDC 2000 BASIC System is a significant security feature. It provides the operator not only with indications of equipment malfunctions, but also provides him with indications of appropriate corrective actions. For example, the operator may use the keyboard to restart a stalled controller. Or, he may use the keyboard to manually manipulate controller loop outputs. If equipment repair is required, he can use displayed data to direct repair personnel. In any case, it allows the operator to respond to equipment malfunctions quickly and positively, minimizing the effects on process operation.

Summary

The TDC 2000 BASIC system has proven its effectiveness in over a thousand varied process applications. This effectiveness is the result of comprehensive control capabilities, sophisticated operator interface capabilities and outstanding reliability and maintainability that are built into the system. It is also the result of built-in flexibility, which allows the TDC 2000 system to be tailored for specific applications not only initially, but as process requirements change.

Continuing system enhancements provide examples of flexibility that will ensure the continuing effectiveness of the TDC 2000 BASIC system. The Extended Controller, which provides significantly enhanced control capabilities, was introduced recently but can be incorporated into any TDC 2000 BASIC system in operation. Similarly, the newly introduced Box Diagnostic display and enhancements to other displays can also be incorporated into any TDC 2000 BASIC system.

If augmented capabilities are required for advanced process managements and process optimization, the TDC 2000 BASIC system may be incorporated directly into a Honeywell Advanced Control system. The TDC 2000 BASIC system may be incorporated either initially or when upgrading; in either case, its components, features and benefits are retained.

The examples of flexibility cited above are typical at the Honeywell TDC 2000 family of systems. Modifications or upgrades are straightforward and economical, and disruptions of process operations are minimized.

Because of its unique features, the TDC 2000 BASIC system has proven its effectiveness from viewpoints of both utility and cost. Because of its ability to adapt to changing requirements, the effectiveness of the TDC 2000 will continue to be proven in the future.

M. Foxboro

SPECTRUM FUNCTIONAL ELEMENTS

OPERATOR INTERFACE

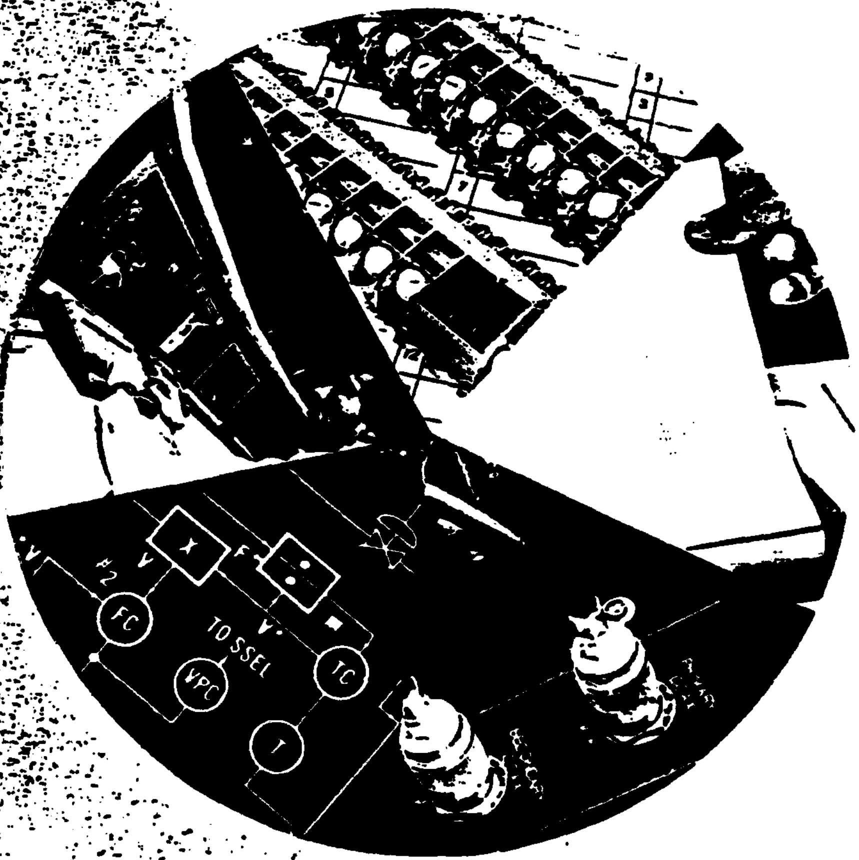
Presenting just the right amount of information to the operator in an understandable format is an important requirement. SPECTRUM solves your operator interface problems with an advanced workstation that provides centralized presentation of just the right amount of information at the right time, and accepts fingertip input of directions and control actions.

PROCESS INTERFACE

A process plant has requirements for interfacing many varied measurements to the process control system. SPECTRUM solves your most difficult process interface problems with two analog and three microprocessor-based subsystems for multiplexing and converting a wide range of process data.

PROCESS MANAGEMENT

Making the best decisions on what to do, and when, can be a problem because timely information is difficult to obtain. SPECTRUM solves your process management problems with two levels of process management capability. The FOX 3 computer provides extensive process data collection and reporting facilities, while the FOX 1/A provides historical data collection, comprehensive information reduction, and flexible reporting capabilities.



PROCESS CONTROL

Obtaining the best control for a process unit requires a control system with the capability of implementing a variety of control solutions ranging from conventional three-mode regulatory control to more complex feedforward and interactive control. SPECTRUM solves your toughest control problems with two choices of control technology . . . *within the same system!* MICROSPEC advanced microprocessor-based regulatory controllers, and SPEC 200 dedicated analog controllers, feature *exceptional* process security, reliability, flexibility, and control and computation capabilities.

COMMUNICATIONS

Implementing integrated control and effective process management is usually a problem because of the difficulties and expense of transmitting the large amounts of required data. SPECTRUM solves your local and long-distance communication problems with a *microprocessor-based* communications link called FOXNET. FOXNET provides *exceptional* communications integrity, network security, and configuration flexibility. It permits practically any control system configuration imaginable, and can provide dramatic savings in field wiring, installation, and future expansion costs.

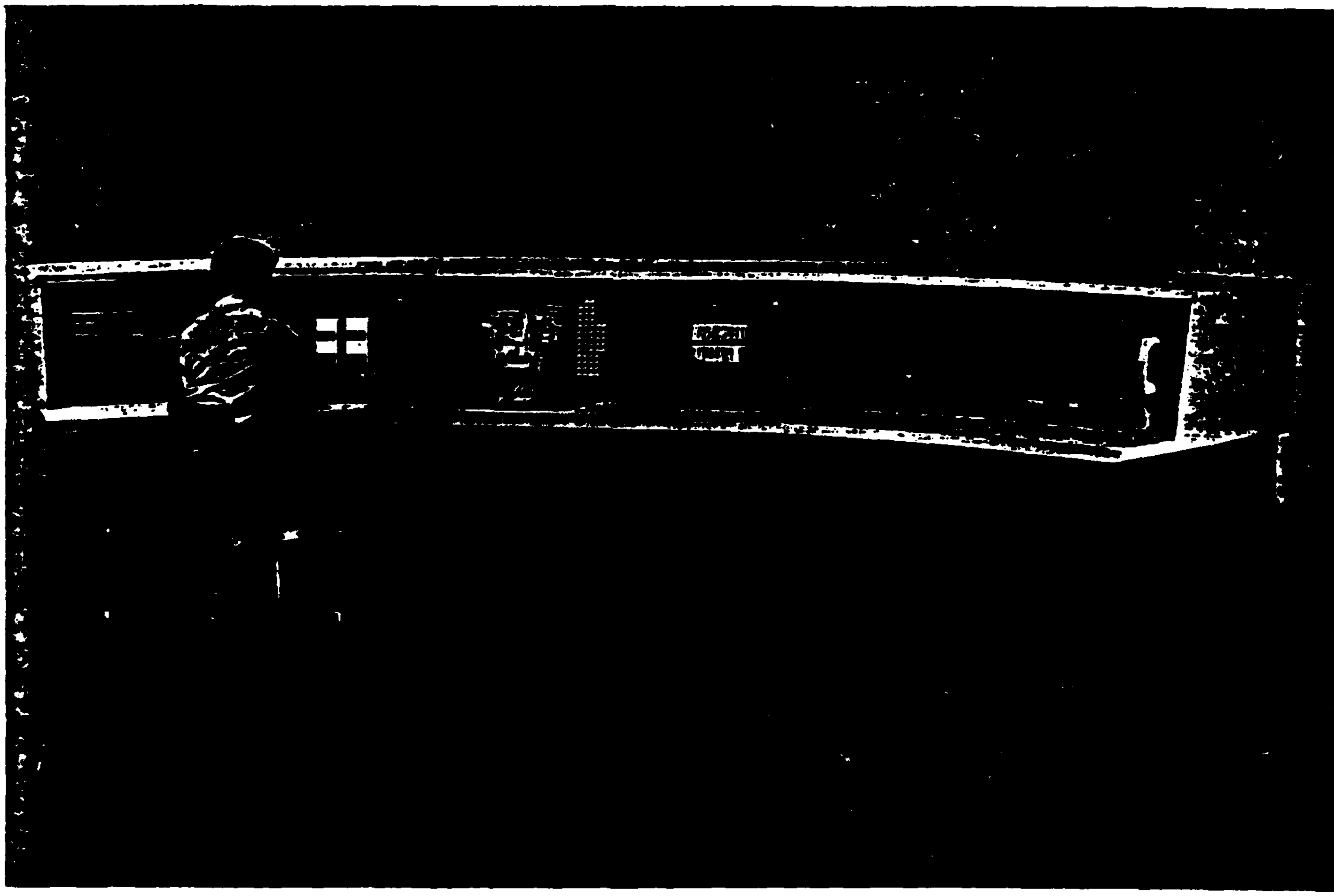
M. Foxboro–Spectrum

OPERATOR WORKSTATIONS

SPECTRUM centralizes the operator interface into what is probably the most compact and comprehensive operator's workstation anywhere. This efficient workstation is based on video displays which enable the operator to look at — and into — the process in whatever degree he desires. They provide him with all the information he needs to understand what is happening and to make decisions regarding any control actions. Complementing the video displays are simple, easy-to-use keyboards for selecting displays and effecting control actions. Just a glance and a touch away!

SPECTRUM workstations consist of various modular bays bolted together to form a single unit. They include one or more VIDEOSPEC, FOX 3, and/or FOX 1/A display bays, and may include a VIDEOSPEC processor bay, an alarm bay, and possibly a recorder bay. Extra bays can be added at any time, as they are needed.

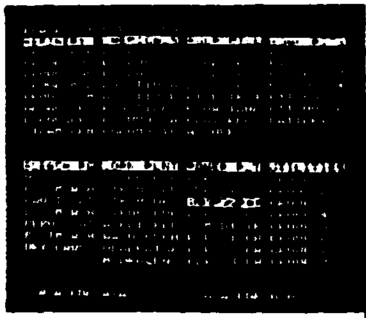
VIDEOSPEC is especially well-suited for operator workstations, as it was designed specifically as an operator interface. It can easily provide the basic displays needed by a SPECTRUM system. These include a hierarchical family of process displays, as well as system operation and configuration displays, in black-and-white or multihued color. The FOX 3 can also provide basic displays, in different alphanumeric formats. When used in conjunction with VIDEOSPEC, the FOX 3 enhances the operator interface by providing process graphic displays as well. The FOX 1/A in turn expands the display capability of workstations manyfold. It adds higher resolution bitmap graphics, a keyboard for easily designing graphic displays, and additional displays containing a much greater variety of data.



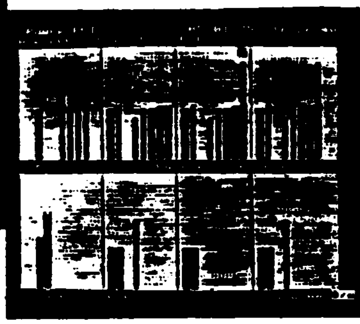
M. Foxboro –Spectrum

PROCESS DISPLAY HIERARCHY

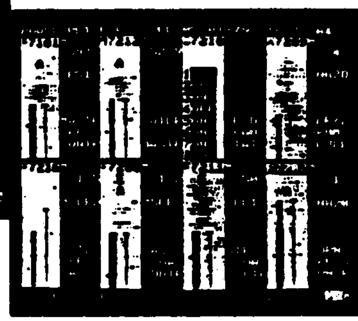
VIDEOSPEC arranges its process displays into a plant/area/group/loop hierarchy. This arrangement makes it very easy to go from an overview display down to a specific loop and examine it in detail. With the variable function keyboard, the operator can go from level to level and page around a level by pressing just one key at a time . . . often the same key.



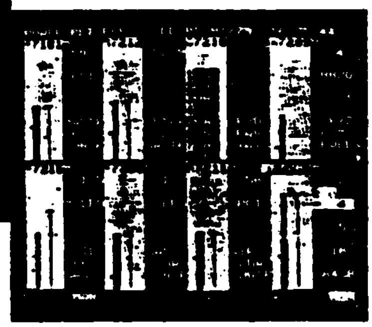
Plant level displays provide normal/alarm status overview.



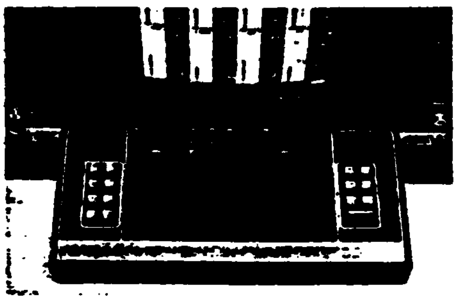
Area level displays provide comprehensive operating data.



Group level displays provide in-depth unit understanding.

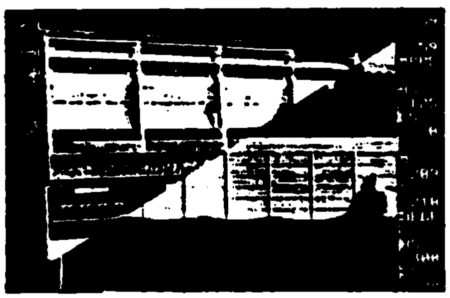


Loop level displays provide specific access and control.



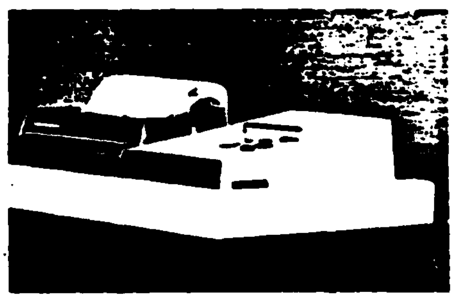
Variable Function Keyboard

VIDEOSPEC uses unique keyboards with both fixed and variable function keys. The fixed function (labeled) keys select various types of operations, such as alarm-handling, trending, recording, system configuration, etc. The variable function keys are assigned different functions depending on the current display. Together they provide, in conjunction with the displays, a small, compact, and extremely easy-to-use man/machine interface capable of performing all necessary functions, from monitoring and controlling the plant to configuring MICROSPEC. Two keylocks restrict access to specified operator interface and control functions, respectively.



Trend Recording

VIDEOSPEC provides both real-time and historical trending and recording. Any measurement can be accessed for real-time trending on a display and/or on one of 16 recorder pens. Measurements can also be stored on a flexible diskette for 8 or 24 hour historical trend records, and the historical trend from the current day's or any previous day's diskette can be displayed and/or recorded at any time. The Recorder Bay also permits up to 99 hard-wired variables to be selected for trending.



Permanent Records

VIDEOSPEC can provide permanent records of any display just by pressing a key. Thus all MICROSPEC and VIDEOSPEC block configurations and changes, as well as any unusual process conditions, can be easily documented. And to aid shift changes, logs of all current alarms, all suppressed alarms, and all loops off-scan can be printed at any time.

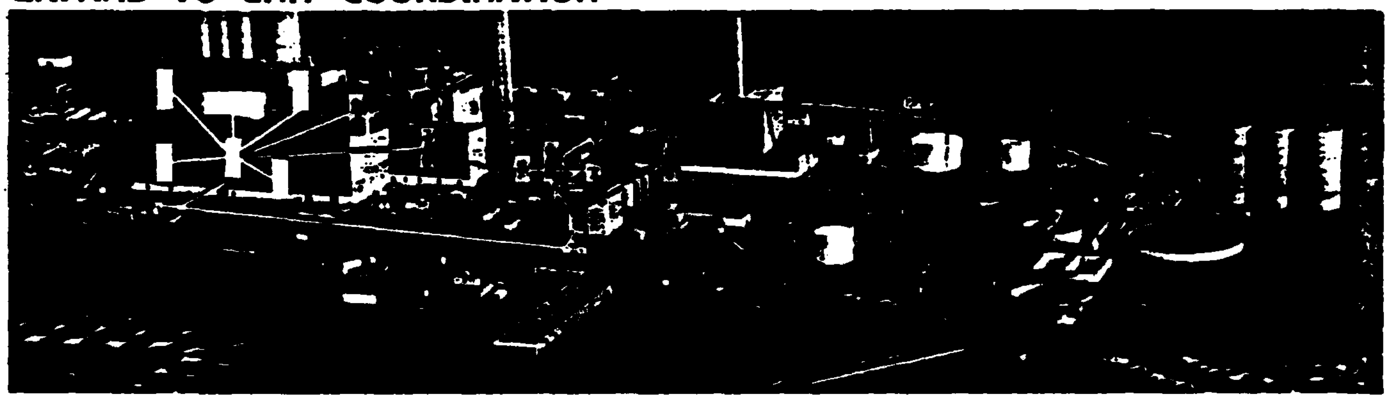
M. Foxboro–Spectrum

SPECTRUM can grow . . . and evolve . . . and change . . . to meet current plant needs at any time.

BEGIN WITH BASIC REGULATORY CONTROL

Versatile SPECTRUM technology permits starting small, with a basic system that provides cost-effective regulatory process control in any area of a plant. Local configurations can use MICROSPEC and/or SPEC 200 to provide basic regulatory control . . . other I/O devices for interfacing noncontrol points . . .Operator SPECTRUM Workstations for viewing the process and making changes . . . and FOXNET to tie it all together.

EXPAND TO UNIT COORDINATION



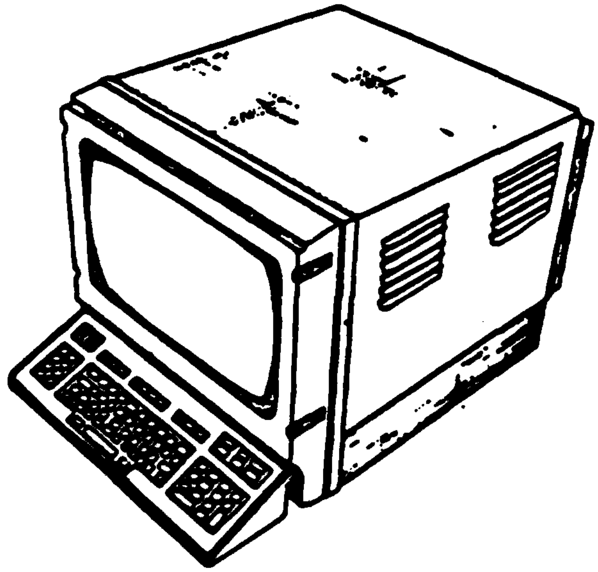
As control needs increase, SPECTRUM provides an ideal framework on which to expand. Additional control, operator interface, process I/O, and FOX 3 computer capability can be provided wherever needed in the plant. The FOXNET communications subsystem allows remote control rooms and equipment centers to be easily connected into the SPECTRUM network. Information gathered at all locations is available throughout the system.

GROW INTO TOTAL PROCESS MANAGEMENT AND CONTROL

To integrate plantwide operations and achieve overall process management and control, SPECTRUM systems permit adding the FOX 1/A computer system to enhance and expand total systems capability. The Workstation concept provides a centralized Operator Workstation to monitor and control remote areas, while local workstations oversee distributed unit operations.

N. Gould - Modicon

Modvue Touch-Station



TYPE	EQUIPMENT	FUNCTIONS
TOUCHSTATION	• color monitor	• plant monitoring and manual supervisory control
	• graphics controller (in IGP)	• display design and configuration (requires keyboard)
	• keyboard (optional)	• independent display and control
	• touch-screen	
	• programmable alarm output relay (klaxon) - connector provided	
	• programmable tone generator and connector provided	
VUESTATION	• color monitor	• plant monitoring
	• graphics controller (in IGP)	• display requested from a TOUCHSTATION
	• programmable alarm output relay - connector provided	• Image is independent of the image on the TOUCHSTATION
	• programmable tone generator and connector provided	
SLAVESTATION	• color monitor	• Plant monitoring
		• Duplicates the image being presented on the TOUCHSTATION or VUESTATION to which it is connected

Two types of mounting are available for all video-stations - 19" rack-mount or a desk mount.

N. Gould–Modicon

DYNAMIC TRACKING OF VARIABLES

Any register type plant variable or its derivatives can be tracked dynamically on the MODVUE Video-stations. These trends can be presented to the operator either via bar charts or point plots. Each tracked item can be linked to a contrasting color. Trend lines change color when thresholds are exceeded.

A MODICON standard template will support up to six data points, each with a different color, can be plotted on a single set of axes. Bar charts can accommodate a maximum of two data points. Bar charts can change color with variations in the value of the associated variable. A third color is employed for overlapping regions.

Trend intervals are user selectable, but trends of up to an 8-hour period can be displayed.

CUSTOM HISTORICAL TREND DATA

MODVUE also provides a capability whereby a user can create customized historical trend data. Specified process variables are accumulated continuously and their history can be displayed in a chart form upon demand or at scheduled intervals. The acquisition and storage of data occurs independent of the current screen contents.

BATCH RECIPE DISPLAY/LOADING

For batch operations, MODVUE provides the capability to define, store, retrieve, and display recipe data. A recipe is a collection of data comprising operational parameters, set-points, and process sequencing instructions for different batches or mixes of product that may be required to be processed.

Recipes can be down-loaded from MODVUE to the programmable controllers connected to it. The programmable controllers must be programmed to receive new recipes and have logic to change their operations in response to such recipes.

PID LOOP CONTROL

Process control loops can be depicted as conventional controller face plates with loop descriptions. Loop tuning parameters and process variables can be displayed and modified by touching graphic "soft" buttons on the TOUCHSTATION video screen. Process loops can also be tracked for trend data.

Use of PID loop control in MODVUE assumes that the programmable controllers connected to it have PID algorithms implemented in them.

N. Gould-Modicon

Item I

Benefits of Programmable Controller Implemented PID

Programmable Controllers, because of their logic capability, can implement a number of unique features with respect to PID. Some of the most significant features are: automotic control systems with reduced operator intervention and set point modificaticm while running. Programmable Controllers, because of their table to register move capability, can profile set points in any desired fashion needed to control a process. In addition, all of the PID variables are highly visible inside of the programmable controller. This allows accurate recording of all process variables! The programmable controllers have the built in ability to print messages, do data logging and other logical functions. Because of these abilities, it is possible to build an integrated control system which requires little if no operator intervention. One of the greatest problems in process control is the fact that the operators learn each of the process operations involved and store a great amount of that process control information in their heads. The control process operator is an extremely valuable individual, however, when these individuals are absent from work or change jobs, it often reduces the ability of a process plant to produce the best quality product. Because the programmable controller has extremely high visibility, both to the logic inside of the programmable controller and to other devices such as CRTs and printers is possible to document all the set points and gain factors presently being used in the system when full production is achieved. This ability will lead to much greater yields in process products. Programmable Controllers can multiplex internally numerous control loops simultaneously with repeat rates below one second. In the case of 8 thermal control loops, a repeat rate of one second is more than adequate

N. Gould-Modicon

to control these processes. 32 loops of process control can be solved by the programmable controller every 2 seconds. In this instance, a great amount of economic saving can be yielded by using programmable controllers to implement the control loops. Traditionally, with DDC control these control loops are made adaptable. However the other logic needs must be supplied by a computer. The Programmable Controller is ideally suited to provide these logic needs. With the programmable controller, the gain factors for the three modes of control can be changed while on line and running. No operator is necessary to change those control parameters. One of the most common uses of Programmable Controllers in process control is monitoring and announciation.

O. Measurex 2002

EnergyMaster multi-boiler control system can cut your fuel costs by as much as 4% immediately.

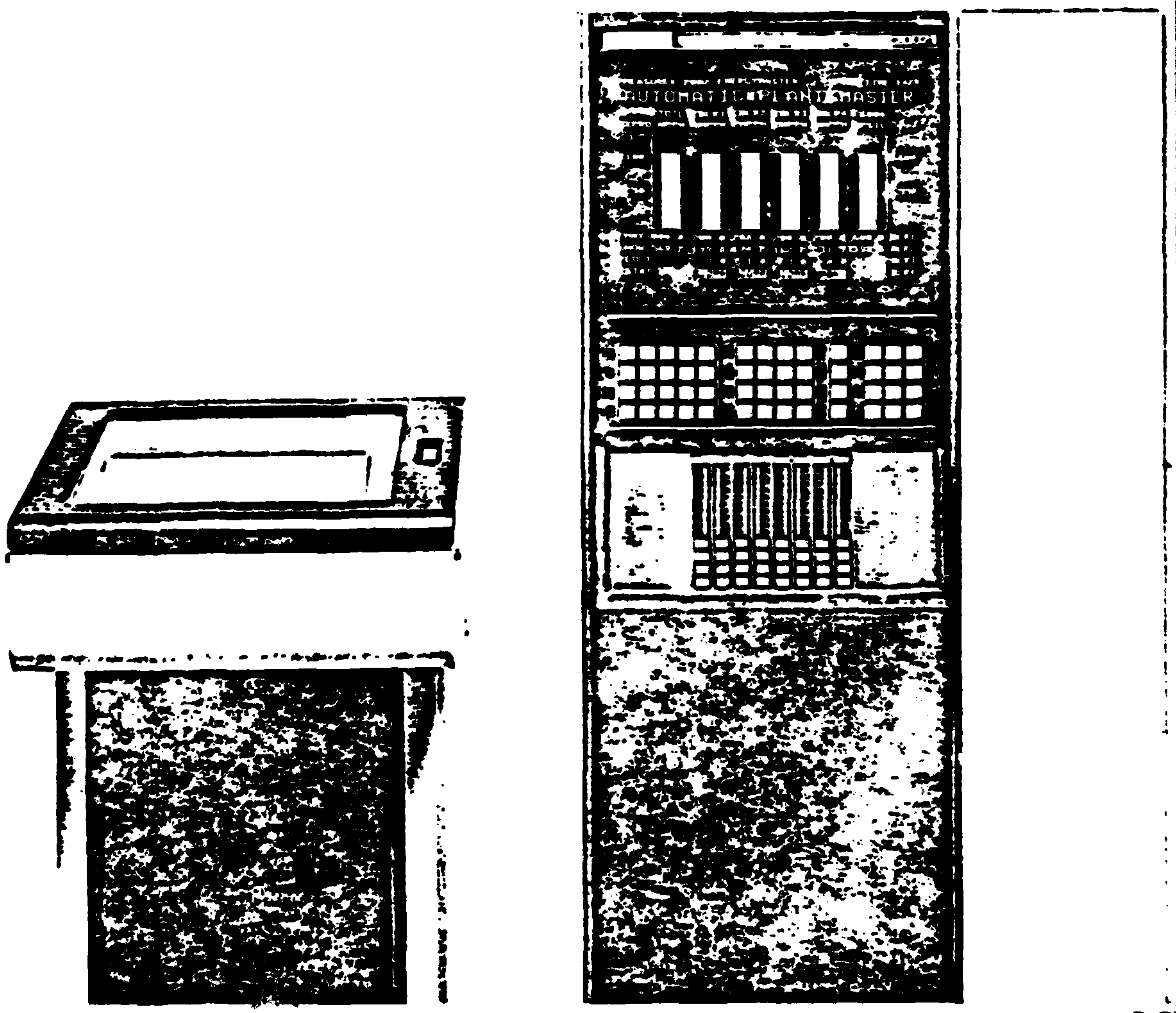
With the Measurex Energy-Master control system, fuel-saving technology is available to powerhouses with up to four boilers and producing as little as 25,000 pounds of steam per hour.

This compact, reliable, low-cost, multi-boiler control system can be operational and saving fuel within one week. Within one year, the savings from reduced fuel costs can pay back your initial capital investment.

The EnergyMaster system approach to providing your plant's steam requirements as cost effectively as possible begins with accurate, reliable CO and CO_2 measurements from our DynaCO sensor. These measurements enable the system to determine and control the precise amount of air required for combustion in each boiler. By reducing excess air, heat loss is decreased and fuel is saved.

To improve plant-wide efficiency, the EnergyMaster allocates steam demand optimally throughout the entire boiler complex. The system determines the optimum distribution of load based on boiler efficiency curves

MEASUREX' ENERGYMASTER™ SYSTEM



O. Measurex 2002

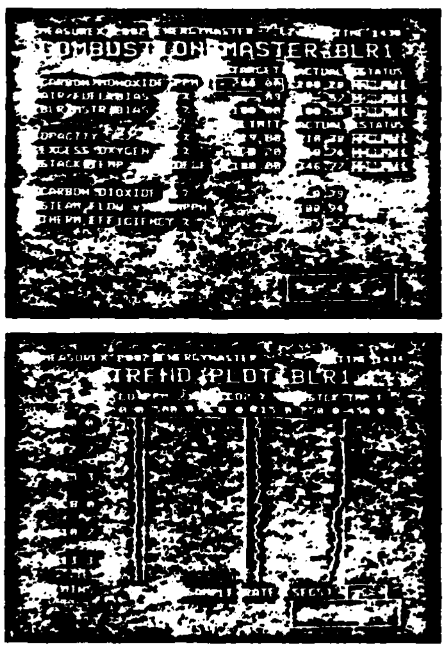
and fuel costs. By selective distribution of steam load among boilers, the system enables you to meet your steam demand at the least cost.

While the EnergyMaster control system provides these direct cost savings through sophisticated microcomputer and sensor technology, it is a system designed especially for ease of operation. A single video display provides the operator with both detailed information on any boiler, and a comprehensive overview of the entire powerhouse operation. At the operator's choice, boiler control displays, trend plots, and statistical data may be printed. Minimal training of operating personnel, low maintenance and high reliability ensure operator acceptance and greatly enhance the system's cost effectiveness.

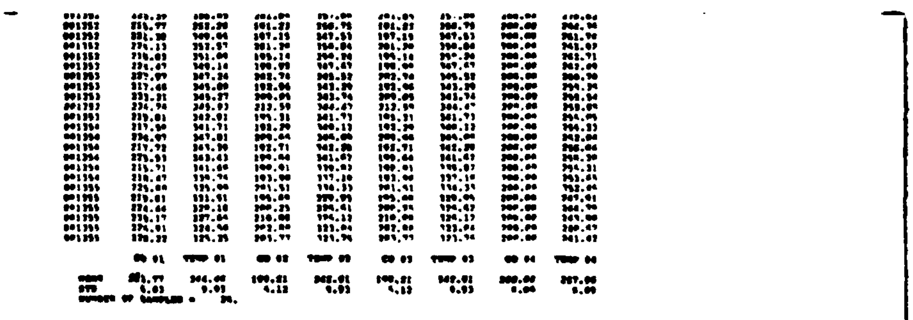
Powerhouse Operating Summaries are printed by the Intelligent Graphic Printer at shift end, daily and upon request, helping operators and management evaluate costs and operating performance. Steam production, fuel consumption, steam cost and thermal efficiency are printed for each boiler and for the entire powerhouse.

The EnergyMaster control system installs quickly, so energy saving results are immediate. The EnergyMaster control system interfaces directly with your existing boiler controls; no costly replacement of instruments is necessary. And as your needs grow, the EnergyMaster system can be readily expanded, to meet your needs for more control.

Measurex' EnergyMaster system. A great way to start saving energy dollars.



Central Interactive Operator Console With VIDICOPY™ for Printing All System Video Displays


VARITRAK™ Tracks Multiple Process Variables

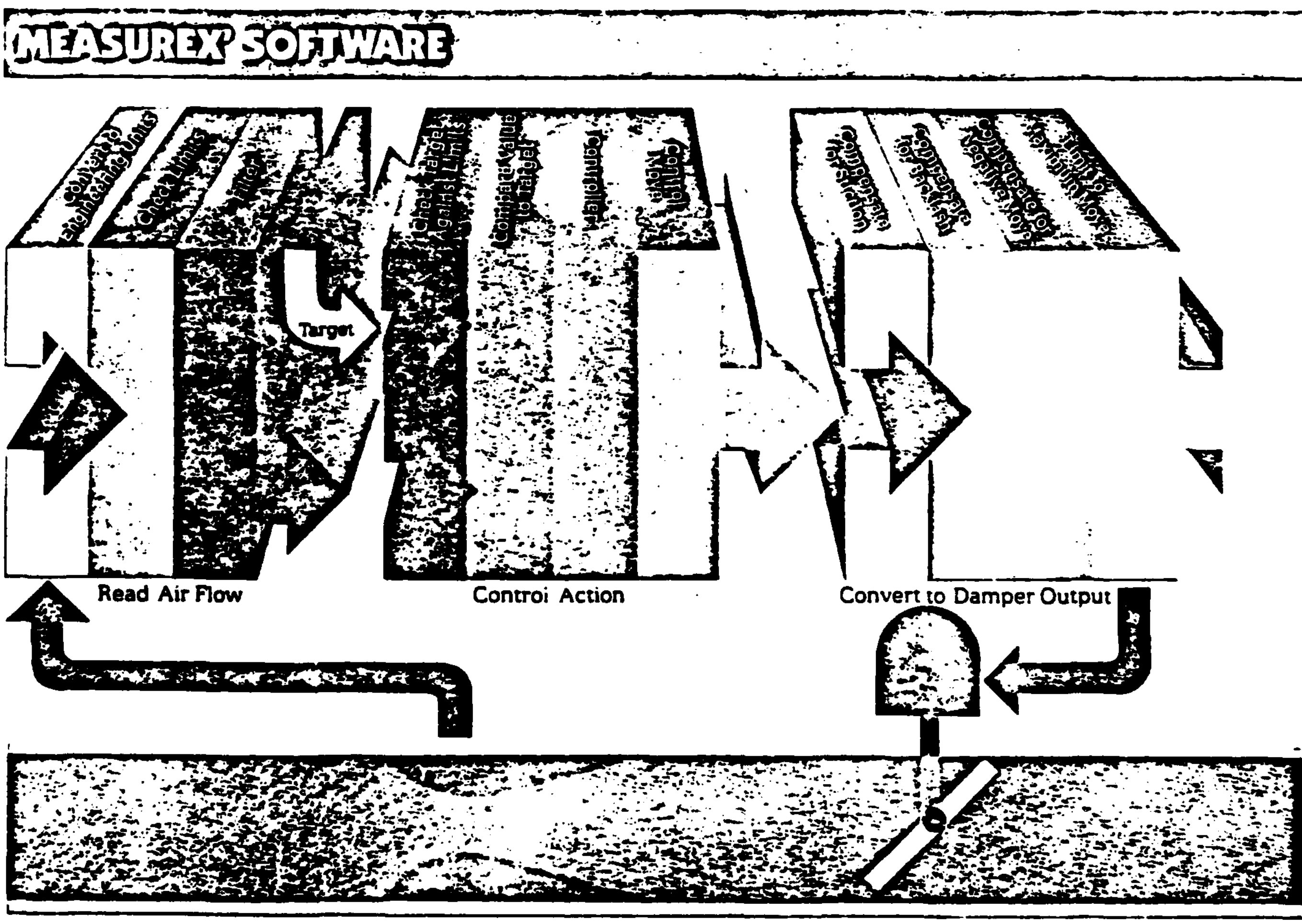
O. Measurex 2002

Our software delivers big savings in time and money, as well as energy.

Measurex' BLOC II™ software is designed to get your control system on-line sooner, to keep it running well without delays for debugging, and to continue to serve you well as your needs grow and change.

Measurex' BLOC II softwar controls the sensors, and processes the measurement data; i configures all control strategies, generates all operator displays, and formats all energy information reports.

Well over 60 man/years have been invested in designing and proving this energy-saving software. Over 120 algorithms (BLOCS) are available—all field-proven, all debugged, all ready t work for you—with no costly investment of your staff's time.



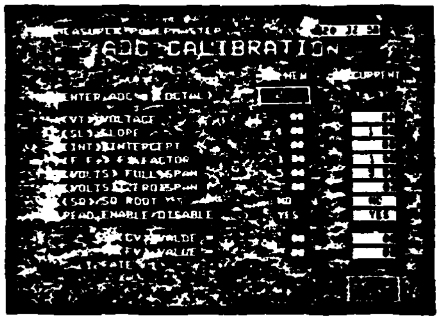
Air (Combustion) Flow Loop Application
BLOC II Software

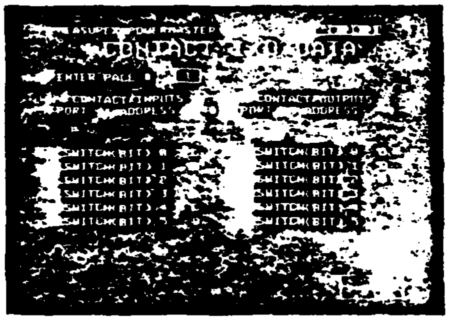
O. Measurex 2002

Your Measurex energy management and control system is custom-made for your powerhouse. It uniquely addresses the opportunities for energy-saving in your operation. The system software is factory-assembled by us, from our extensive library of algorithms. And it is extensively pre-tested prior to shipment and installation, for rapid start-up. Further enhancing rapid start-up are Measurex' video displays, which enable you to enter and adjust calibration and control tuning data.

If and when your needs change, your Measurex software can be easily changed—in the field—to accommodate your requirements. Either by us, or by your own staff.

Measurex' BLOC II software. It'll help you start saving energy faster, without spending time and money on programming.





Interactive Videos Shorten System Installation Time

P. Fisher-PRōVOX

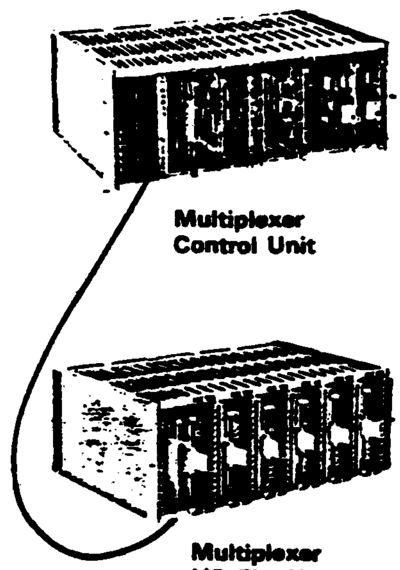
instruments to meet all process control needs

PRōVOX instrumentation systems include continuous controllers, batch controllers, data acquisition multiplexers, process manager consoles with data logging, general purpose computers, and communication network products that provide efficient interaction between the instruments. Various combinations of these instruments provide both conventional and new process control capabilities.

Better Process Management through Broad Process Knowledge

The individual controllers provide and maintain their own process data bases. The data bases are made available to the control system via the communication system data highway.

Data acquisition multiplexers gather data from your field sensors and funnel it to process manager consoles via the data highway. Since the highway may be several thousand feet long, installing multiplexers near field transmitters eliminates miles of expensive multi-pair field wiring. Besides acquiring data from your field transmitters, the multiplexers provide one means of operator control of field devices. For example, your operators can start and stop motors or feed remote set points to existing analog control systems.

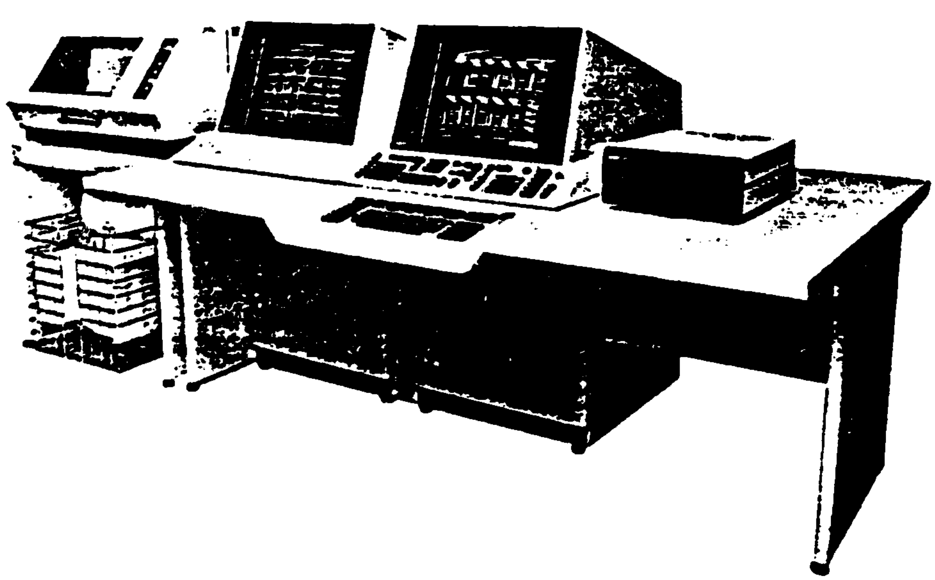


DATA ACQUISITION MULTIPLEXER

Better Process Management through Flexible Operating Centers

Process manager consoles are the operating center of the distributed system. Your operators monitor and supervise your continuous and batch control operations from these consoles. The process manager consoles can be categorized into two general types: consoles with preformatted displays only and consoles with preformatted displays plus custom graphics.

The preformatted displays of both console types only require adding your tag numbers, names, and engineering units. The display format is human-factors engineered so that your operators find the displays easy to use.



PROCESS MANAGER CONSOLES FOR DISPLAY OF ACQUIRED DATA AND OPERATION OF CONTINUOUS AND BATCH CONTROL PROCESSES

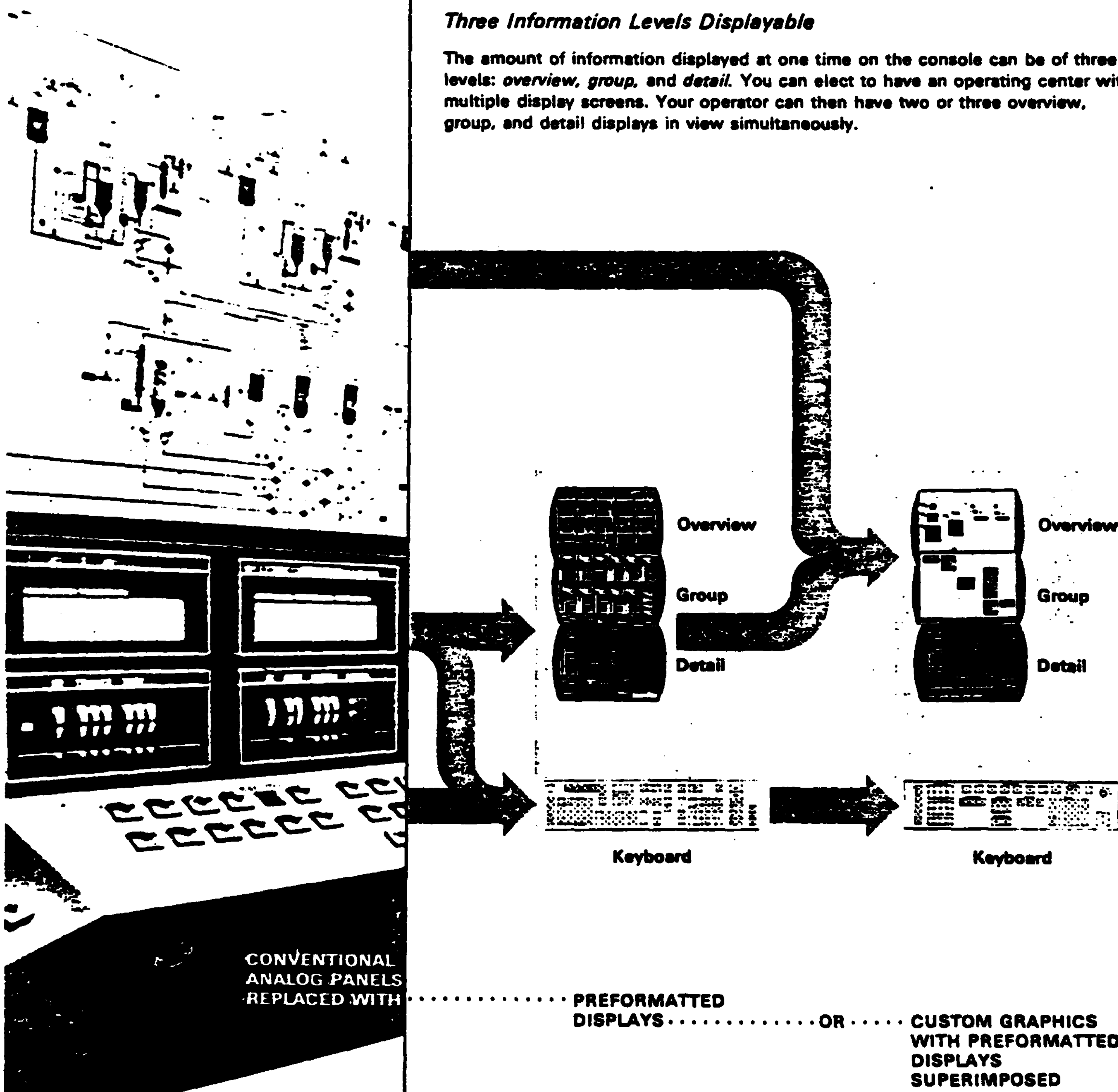
P. Fisher-PRöVOX

Familiar Operating Displays

Conventional analog control panels are typically separated into three areas: an uppe area showing a graphic drawing of the process or plant, a middle area containing the operator stations, and a lower area holding motor control switches. Our proces manager consoles can replace the conventional analog panels. All consoles provide middle area displays using *faceplates* that resemble the many operator stations. They also provide motor control through the console keyboard. In additio custom graphics consoles provide all three areas of the conventional analog control panel by including graphic drawings of your process or plant.

Three Information Levels Displayable

The amount of information displayed at one time on the console can be of three levels: *overview, group,* and *detail.* You can elect to have an operating center wit multiple display screens. Your operator can then have two or three overview, group, and detail displays in view simultaneously.



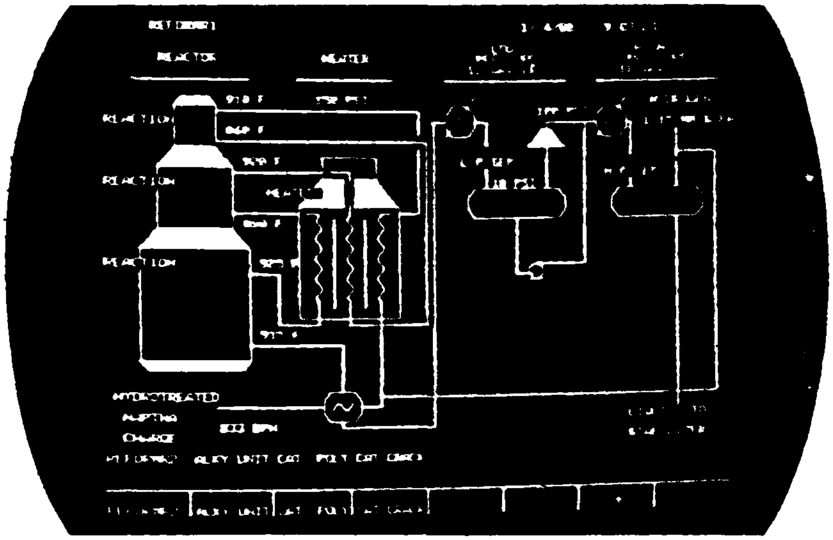
REPLACE CONVENTIONAL ANALOG PANELS WITH FLEXIBLE CONSOLE DISPLAYS

P. Fisher- PRöVOX

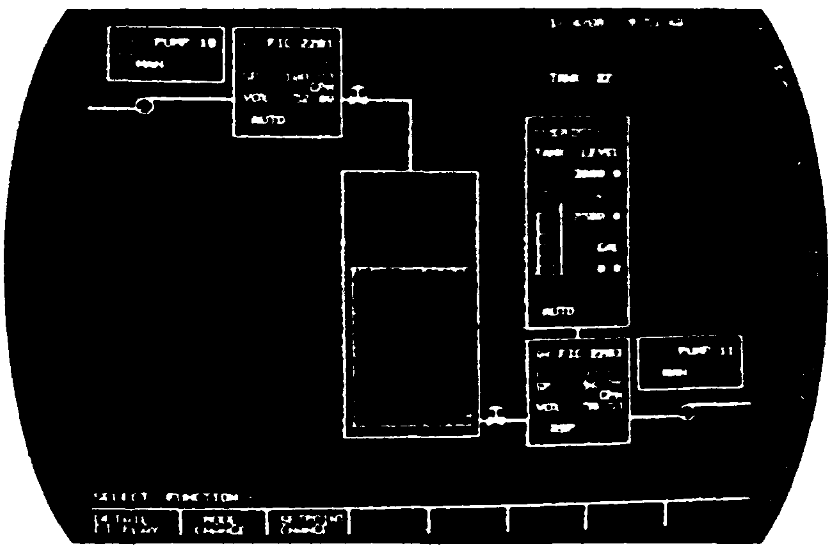
Custom-Graphics-Display Approach to Operating Displays

Inclusion of custom-graphics process manager consoles in your system enable your operators to see faceplates superimposed over graphics displays of your process. This lets them put viewed data into perspective. With custom-graphics consoles, they may also use preformatted displays similar to those already described.

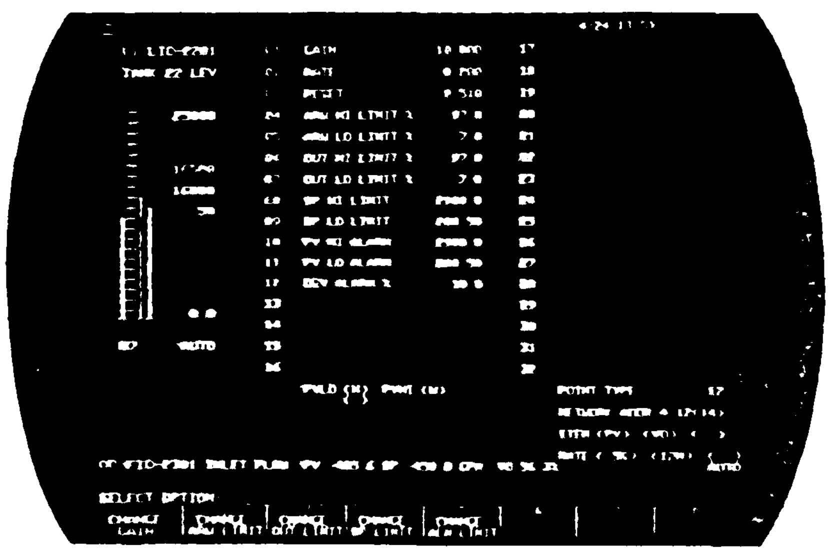
Overview Displays:
- **See plant condition at a glance using graphic overview drawings**
- **Exceptions are highlighted by tag number color changes**
- **See dynamic operation of process**



Group Displays:
- **Zero in on a process problem by expanding graphics display**
- **Perform operator control**
- **Faceplates superimposed on graphics displays**
- **See dynamic operation of process**



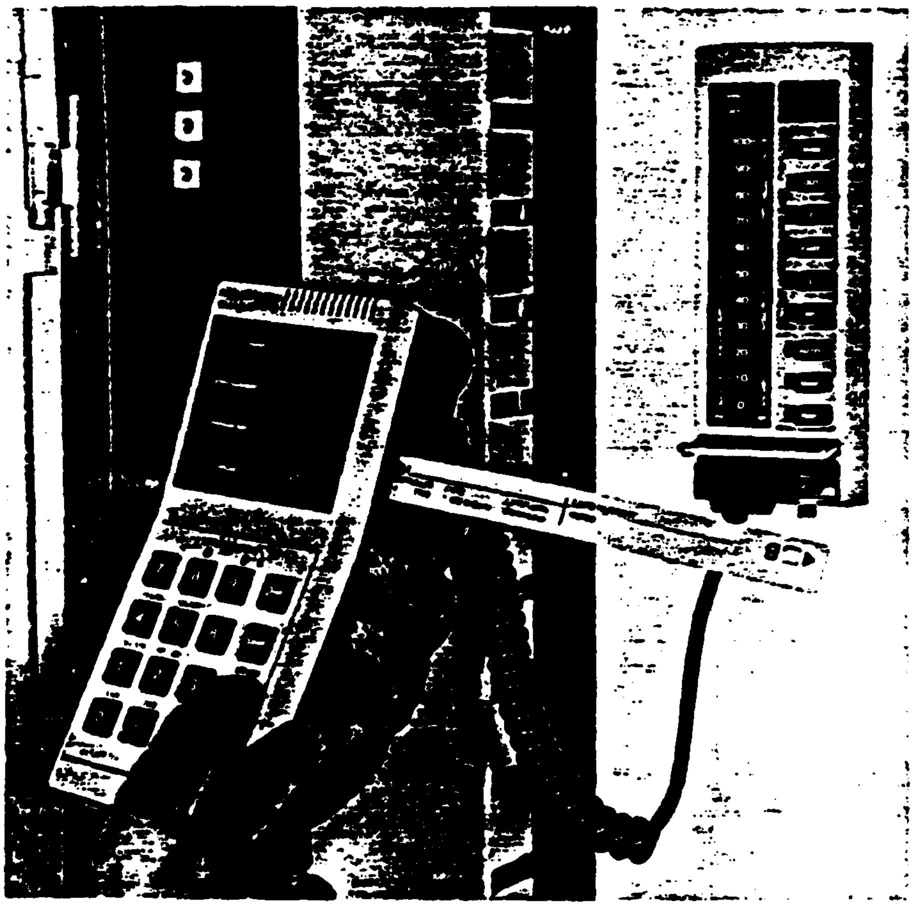
Detail Displays:
- **Look at the faceplate of a single control loop**
- **Manipulate specific tuning and engineering setup parameters**



P. Fisher-PRöVOX

Easy to Tune

Original tuning and configuration data is normally entered into the system controllers via the process manager console. Loop tuning may also be done with pushbutton ease using the hand-held tuner. The tuner is plugged into the front of the operator station. Tuning data is then entered into the controller using the pushbutton keyboard on the tuner. After the controller is tuned, a copy of the tuning data may be stored on a magnetic card by running the card through the tuner. Configuration data may also be stored on a tuner magnetic card. Tuning and configuring a replacement controller is easy. If, for any reason, the controller is replaced, the data on the magnetic cards is used to tune and configure the replacement. Simply plug in the tuner and run the magnetic cards through it. The replacement is then configured, tuned, and ready to take control.



HAND-HELD TUNER SIMPLIFIES CONTROLLER TUNING AND CONFIGURATION

TRENDS

View the trend of a single variable.

OR

Compare the trend of two variables.

OR

Compare the trend of three variables simultaneously.

CURRENT AND HISTORICAL TREND DISPLAYS ARE USEFUL FOR COMPARING VARIABLES IN INTERACTIVE LOOPS